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HEATING AND VENTILATION

STURTEVANT

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and all Principal Cities of the World

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INTRODUCTORY

OVER twenty-five years ago, the first edition of a book known as " Ventilation and Heating " was published by the B. F. Sturtevant Company. Since then, the demand for the book by architects, engineers and students has been so great that frequent editions have been necessary. With almost every edition, the editors have endeavored to improve upon the efforts of their predecessors as much as possible, but, until the present edition, no decided change has been made.

The advancement of the science of heating and ventilation together with allied subjects has been rapid and has made it necessary to revise the book completely in order that the information that it contains shall be up-to-date. With this in mind, therefore, the present edition has been prepared, and it is the earnest hope of the Company that it will supply the demand for a book of this character as ably as did former editions.

In arranging the present edition, the Company has endeavored to make it more generally useful as a book of reference by a careful and logical arrangement and by a thoroughly complete index. It has also been the desire of the Company to prepare the book in such a manner that it will be equally useful to engineer and layman. The text matter makes up Part I, and is divided into ten chapters and is further divided into sections, all numbered and provided with titles to aid the reader in finding the information he desires. The arrangement adhered to is as follows:

Chapter I considers air, its composition, properties and physical characteristics.

Chapter II deals with the subject of ventilation, the necessity of ventilation, the way it is measured and the method of supplying mechanical ventilation.

Chapter III deals with heat, heating and various artificial methods of heating buildings.

Chapter IV considers the Sturtevant System, or the hot blast system of combined heating and ventilation.

Chapter V is a general study of the apparatus used in heating and ventilating installations.

Chapter VI is a consideration of problems involved in calculating heating and ventilation systems, the designing of the system and the control and regulation of the system after it has been installed.

Chapter VII is devoted to the testing of the system, the relations between pressure, volume and velocity and the instruments used in making tests.

Chapter VIII is a consideration of the individual problems involved in the ventilation and heating of distinctive types of buildings and rooms.

Chapter IX is a description of typical installations of Sturtevant apparatus and of the Sturtevant System, representative but necessarily meagre, as this subject is more extensively covered by special catalogs dealing with installations almost entirely.

Chapter X describes Sturtevant apparatus briefly, this subject being exhaustively treated in many engineering bulletins and catalogs published by this Company.

Part II is a collection of tables for the use of the student and engineer covering the subject of ventilation and heating in general and Sturtevant apparatus in particular.

The casual reader is spared a technical discussion of subjects in which he has little interest by the arrangement of the book as shown above. If a layman, he may read the first four chapters and Chapters VIII and IX with reference to the others if he so desires, while on the other hand, if more technically inclined, he will find himself supplied with information for reference.

It is hoped that this treatment will make this a book of genuine value and advantage, that it will find a place in the libraries of engineers, architects and students everywhere, and that it will be as widely used as a text-book by engineering schools, as other editions have been.

It is possible that the publication of such information as is contained herein may present an opportunity for competitors to take unfair advantage of the liberal policy under which the information is published. In such a case, we must rely upon the superiority of our product and experience to outweigh the advantage thus obtained, confident that in any actual test of quality or efficiency our apparatus will justify our reputation.

Of the Sturtevant System itself, little can be said here that would not anticipate the contents of the following pages. Its growth in favor and application has proved its worth, while the successful installations to be found all over the civilized world constitute the best evidence that can be offered for its efficiency.

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PART I

HEATING AND VENTILATION

CHAPTER I

THEORETICAL CONSIDERATIONS

1. First Considerations

AIR and life are intimately associated, since air, or its most important element, oxygen, is necessary for all life, animal or vegetable. As the subject of ventilation concerns the relation of air to health, any comprehensive study of ventilation should be prefaced by an understanding of the composition of the atmosphere, the relations between air and life and the effect of the impurities of air upon health. The most efficient and practical method of obtaining ventilation can then be considered intelligently.

2. The Atmosphere

The entire earth is covered with an envelope of air, or atmosphere, having a depth of several miles and, under normal conditions, exerting a barometric pressure of 29.92 inches of mercury. Air may be considered a perfect gas, and, as such, is subject to the laws governing gases. Being compressible, its density is subject to variation according to conditions of temperature and pressure. In its application to heating and ventilation, the change in density due to pressure is too slight to require serious attention. The effect of temperature upon volume is a much greater feature, however, and should be taken into account.

The density of air decreases in geometric ratio as the distance from the surface of the earth increases. For purposes of calculation, therefore, the pressure exerted by the air upon the surface

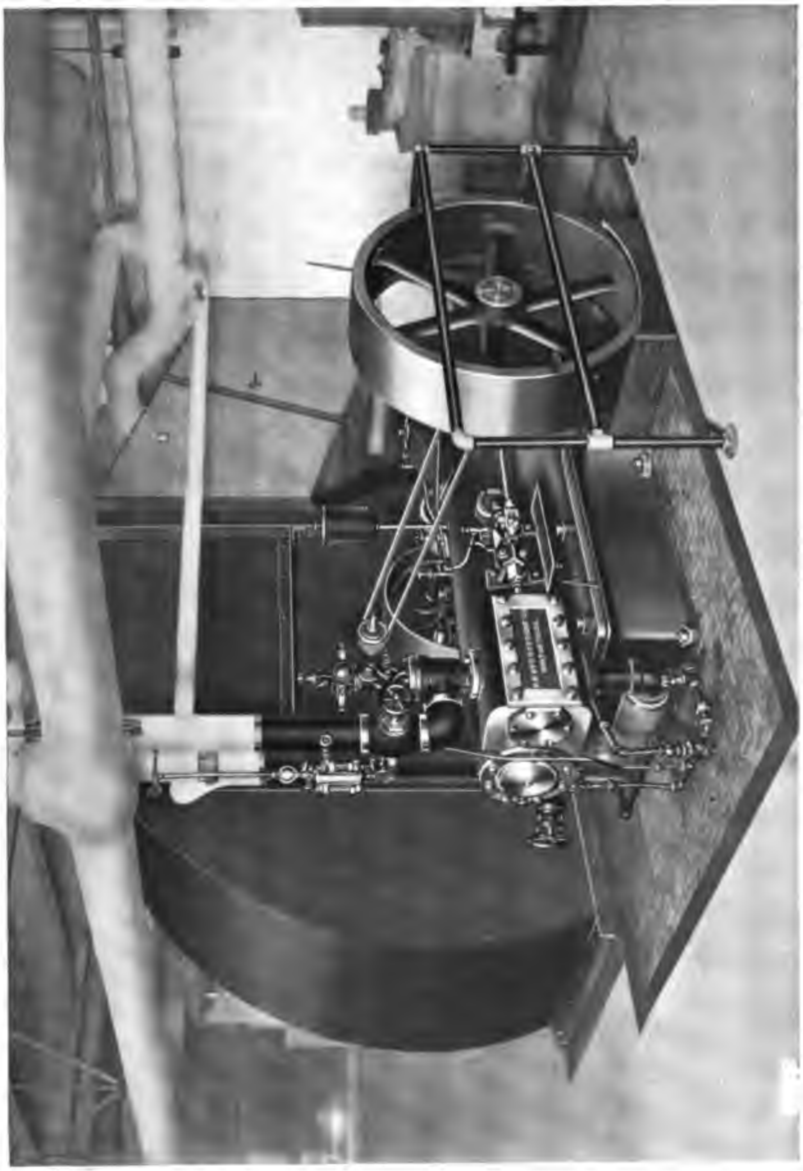

Fig. 1. Ventilating Apparatus, John B. Stetson Co., Philadelphia.

of the earth is considered as being that due to a column of air of uniform density throughout and of a height of approximately 27,000 feet. This pressure, at sea level under normal conditions, is calculated to be about 14.7 pounds per square inch or, as stated above, a barometric pressure of 29.92 inches of mercury.

3. Composition of Air

Chemically considered, air is a mixture of gases, four-fifths nitrogen and one-fifth oxygen. Although air is merely a mechanical mixture, its constituents exist in almost invariable relative proportions, in spite of the endless cycle of chemical change to which they are continuously subjected.

Carbon dioxide is found in all air, existing in about 3 parts in 10,000 of air in places remote from cities, and about 4 parts in 10,000 of air in the atmosphere of the ordinary city. In very small amounts, there is found in the atmosphere ammonia, sulphurated hydrogen, sulphurous acid gas and various nitrogenous compounds. Water vapor, that most important constituent of the atmosphere, exists in varying proportions, dependent upon the proximity of large bodies of water and upon temperature. Dust, micro-organisms and local impurities, such as smoke and the products of manufacturing plants, are found in the atmosphere in widely varying amounts.

4. Composition of the Air by Weight

F. A. R. Russell* gives the composition of the air, by weight, as the following:

Oxygen	1,233,010	Billions of tons
Nitrogen	3,994,593	" " "
Carbon Dioxide	5,287	" " "
Water Vapor	54,460	" " "

---

* "Atmosphere in relation to Human Life and Health." F. A. R. Russell in Smithsonian Miscellaneous Collections, Vol. 39.

5. Oxygen

Oxygen is the life-giving element of the air. It exists in the atmosphere to the extent of about one-fifth of the total volume. In open country or at sea, the average proportion may be stated as about 20.95 per cent. This proportion decreases in the neighborhood of cities and drops in mines to 20 per cent., while in extreme cases a percentage of 18.6 has been recorded.

Chemically considered, oxygen has a strong attraction for the elements, there being only one known with which it does not combine. The process of combination, whether slow or fast, is one of combustion. Thus, brought in contact with the blood, the oxygen is carried to all portions of the body where the process of combustion of the bodily tissues is carried on. The carbon dioxide thus formed is returned to the lungs and expelled in the process of exhalation. From every volume of air taken into the lungs, about 4½ per cent. of oxygen is abstracted.

6. Ozone

Ozone is an allotropic and unstable form of oxygen found at times in the atmosphere but not in great quantities. It rarely exceeds one part in 10,000 of air. Chemically, it is very active and has a beneficial effect upon the air, as it is a powerful oxydizing agent and disinfectant. Its existence is a sign of good air, since it attacks and destroys the impurities in the air.

In too great quantities, however, it is destructive to life, oxygen containing $\frac{1}{240}$ part of ozone being rapidly fatal. The odor of ozone can be readily detected even in quantities as low as 1 part in 2,500,000 of air.

Ozone is formed by the passage of an electric spark through the air; hence its presence after thunder storms is most noticeable. Slow oxydation of phosphorus and of essential oils in the presence of moisture is also productive of ozone.

More ozone is found on mountain tops than at lower levels, while it is most abundant near the sea. Local impurities make its presence rare in the vicinity of cities.

7. Nitrogen

Although four-fifths of the air is composed of nitrogen, this gas is neutral in its action and is merely a diluent. It is taken into the lungs of the body and expelled without change or apparent effect. The relative proportions of oxygen and nitrogen changing, however, would produce the most serious results, for although pure oxygen is sometimes administered in cases of illness, the human system cannot live in it for periods greater than a few hours. Nitrogen is the food of the plants, being taken by them from the ground, as few plants are able to secure their nitrogen directly from the air.

8. Carbon Dioxide

Carbon dioxide, or carbonic acid gas, as it is also called, is only a neutral constituent of the atmosphere, like nitrogen, and, contrary to former impressions, it is neither disagreeable nor particularly harmful, in moderately large quantities — as in soda water manufacture. But its presence in the air provided for breathing decreases the readiness with which the oxygen of the air can perform its functions, and in vitiated air it is an index of the degree of vitiation and is an indication of an impure and unhealthful atmosphere. It is evident, therefore, that when present in sufficient quantities it may indirectly bring about not only serious but fatal results. The true evil of a vitiated atmosphere lies in its other constituent gases and in the impurities which are produced by exhalation. It is known that impurities exist in proportion to the amount of carbon dioxide present in an atmosphere vitiated by respiration. Therefore, as the relative proportion of carbon dioxide may be determined

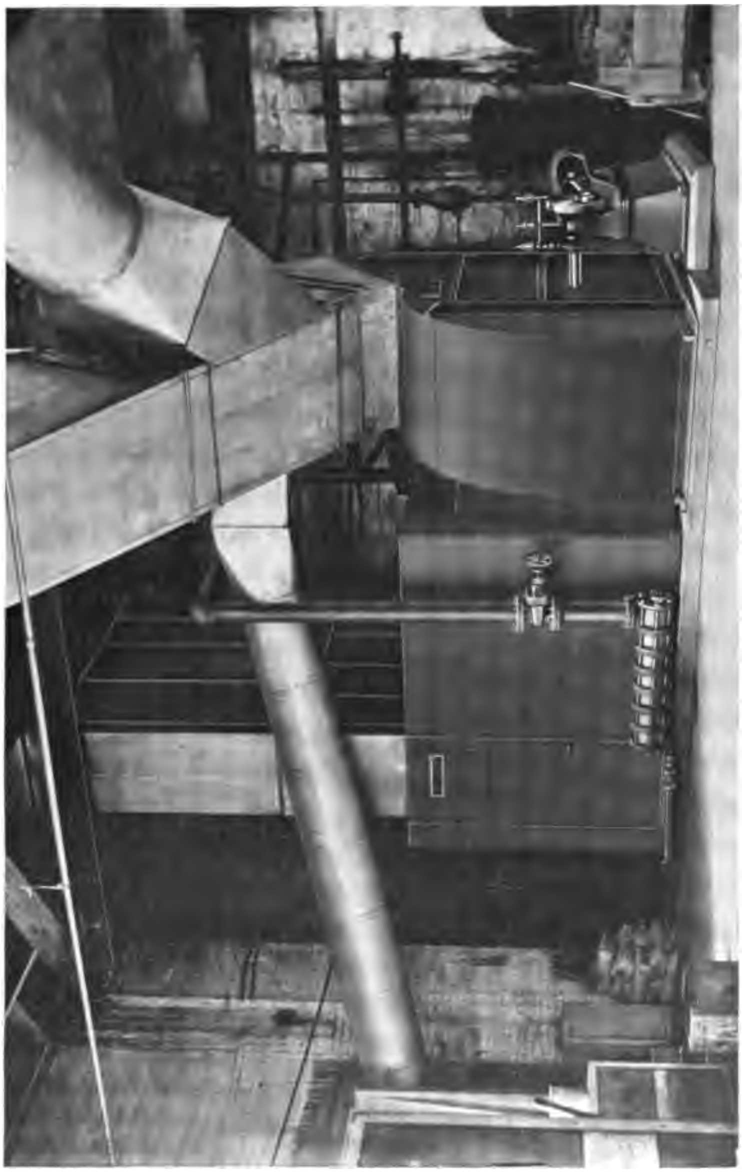

Fig. 2. Sturtevant Heater, Fan and Engine, Diebold Safe and Lock Co., Canton, O.

easily by experiment, the fixing of a standard limit to the amount which may be allowed in ventilated rooms also limits the possible vitiation of the atmosphere by other impurities.

It has been noted in vitiated apartments that when carbon dioxide is present in excess of 10 parts in 10,000 parts of air, a feeling of weariness and stuffiness, often accompanied by headache, will be experienced, while even with 8 parts in 10,000 of air, a room would be considered close. For general considerations of ventilation, the limit should be placed at 6 to 7 parts of carbon dioxide in 10,000, thus allowing an increase of 2 to 3 parts per 10,000 over that normally present in the atmosphere, which is practically 4 parts in 10,000 under ordinary conditions.

The effect of an atmosphere overcharged with carbon dioxide is to produce a feeling of drowsiness, while accumulating in the blood, this gas renders the vital organs inactive.

Carbon dioxide is split up by the chlorophyl of plant life, its carbon being assimilated by the plant and its oxygen returned to the air.

9. Dust and other Impurities

The air at all times contains considerable amounts of dust and other impurities which are important factors to be considered with the subject of ventilation. There is no way of knowing the absolute amounts of these impurities without investigating special conditions, as local conditions affect the amounts greatly. The free air of the country or seashore is more pure than that of the city, while in some instances, the air is so polluted with dust, gases, smoke or fumes caused by manufacturing plants that even the growth of vegetation is severely handicapped. The effect of these impurities upon health varies with the nature and the relative amount of the impurity, one being poisonous while another is merely irritating. In the dust of the city, however, there is apt to be danger from disease germs which are easily transmitted in this manner. Any system of ventilation that is to be complete should therefore include some means by which dust and other impurities can be removed before the air is admitted to the building for breathing purposes.

10. Moisture

There is always a certain amount of water vapor in the atmosphere. The exact amount depends upon many conditions and varies with the barometric pressure and with the temperature. Its presence in the atmosphere of deserts is comparatively slight and the amount is greatly affected by the proximity of large bodies of water. Moisture in the air aids in the diffusion of light and heat. It has an important influence not only on personal comfort but on health as well. The condition of the air with respect to its relative moisture content affects the absorption of moisture from the body, throat and lungs. The ability to regulate accurately the amount of moisture in the air of rooms is a factor of great importance in ventilation. By artificial regulation, the best conditions may be obtained, no matter how unfavorable the weather outside may be.

11. Humidity, Actual and Relative

The condition of the air with respect to the amount of vapor of water which it holds in suspension is expressed by the term humidity. Actual humidity relates to the actual weight of water vapor present in a given unit volume of air, while the term relative humidity expresses the relation between the vapor actually present in the air and that which it would contain if completely saturated. Obviously, air is saturated with moisture when it can hold no more. The actual humidity varies excessively with the temperature. It is evident, therefore, that a statement of the relative humidity gives no indication of the exact amount of vapor present unless the moisture-carrying capacity of the air at the given temperature be known.

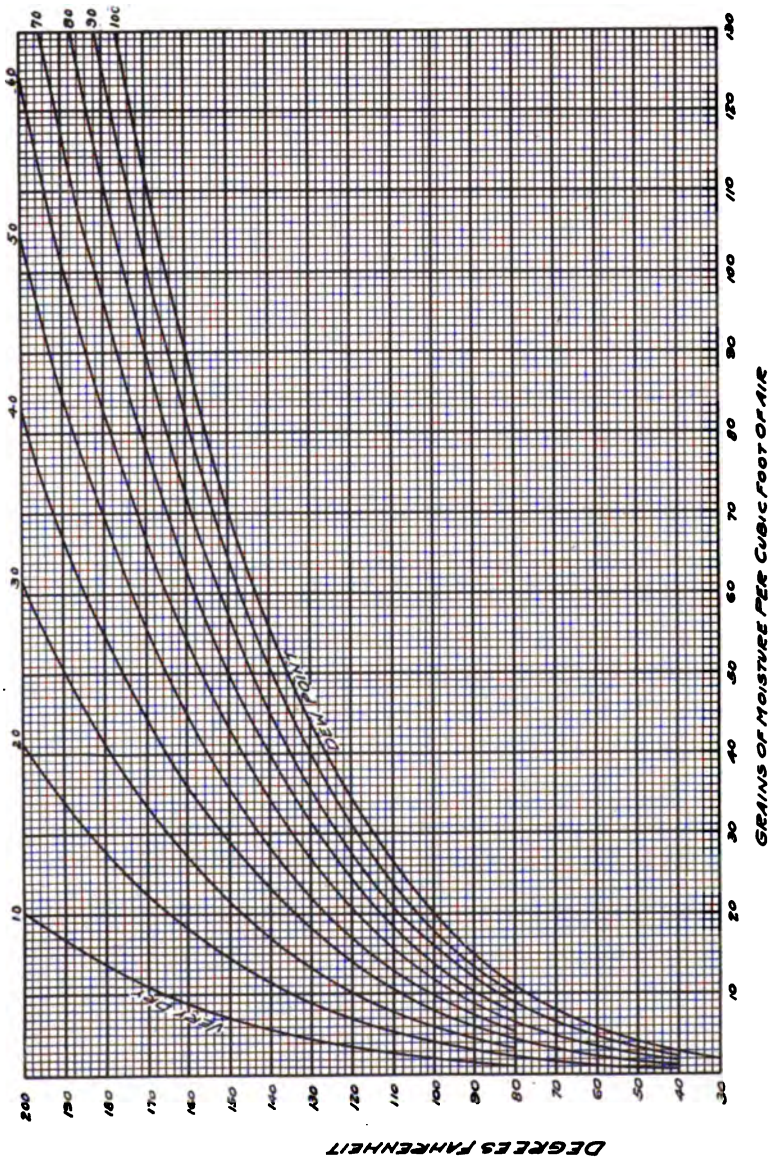

FIG. 3. HYGROMETRIC CHART.

12. Hygrometric Chart

The rapid increase in the capacity of the air for carrying off moisture as the temperature of air rises is shown graphically in the chart of Fig. 3, the curved lines representing the rates of increase for 10, 20, etc., to 100 per cent. humidity. 100 per cent. is the dew point, or the state of complete saturation. The abscissae of this chart are grains of moisture per cubic foot of air while the ordinates are degrees Fahrenheit. Table No. 2 shows the influence of temperature upon the vapor capacity of air.

13. Dew Point

The temperature at which complete saturation is obtained is known as the dew point. If there is any further lowering in temperature when the dew point is reached, some of the moisture in the air will condense. Without a rise in temperature no further evaporation can take place. In other words, a greater amount of moisture cannot exist in a vaporous state at that temperature.

14. Latent Heat of Vaporization

When water passes from the liquid to a vaporous state, considerable heat is absorbed, depending upon the pressure and the temperature at which vaporization takes place. This heat is not sensible of thermometric measurement and does not raise the temperature of the vapor. Upon condensing into a liquid state again, this heat is given up by the vapor. The temperature of the moisture, however, remains the same as that of the uncondensed vapor. The heat so absorbed and so given up is known as the latent heat of vaporization. On the other hand, when moisture evaporates, the heat of vaporization necessary to effect a change of state is supplied from surrounding objects and from the air, with the natural result that, although the temperature of the vapor is not raised, the temperature of surrounding objects and the air is lowered.

This principle may be used in connection with air washing apparatus to cool the air supplied for ventilating purposes. The process is as follows. Suppose air enters an air washer at comparatively high temperature and relative humidity. It is chilled by contact with the cleaning water until the dew point is reached. If the water has a sufficiently low temperature, the moisture in the air will be condensed and the temperature of the air lowered until it reaches a point near the temperature of the water. The heat of vaporization has disappeared, has been absorbed by the cooling water. The air now passes on through the air washer in a more or less saturated condition, yet at a low temperature. If in this condition it is admitted to the building to be cooled, its temperature will rise as it becomes warmed in passing through the ducts and in mixing with the air of the room. As there is little opportunity for more moisture to be absorbed, the relative humidity of the air falls to normal with its rise in temperature.

The conditions existing in winter, however, are directly the reverse of these just stated. The outside air is at a low temperature, the humidity is low, and heating, not cooling, is the desired object in view. Under these conditions, the air must be heated before entering the air washer. This raises its temperature but lowers the relative humidity. By contact with the water in the washer, however, moisture is absorbed by the air, the temperature of the air is lowered and the humidity raised near the point of saturation. Upon raising the temperature further in the heater, the relative humidity is lowered and the air is finally discharged into the room containing sufficient moisture for the most healthful conditions.

With the air washer, therefore, it is possible to raise the moisture content of the air within the building to the most beneficial point. The outside atmosphere contains so little moisture in the winter time that unless there is some means of moistening it within the building, it may be drier than is desirable. A study of the hygrometric chart of Fig. 3 will indicate

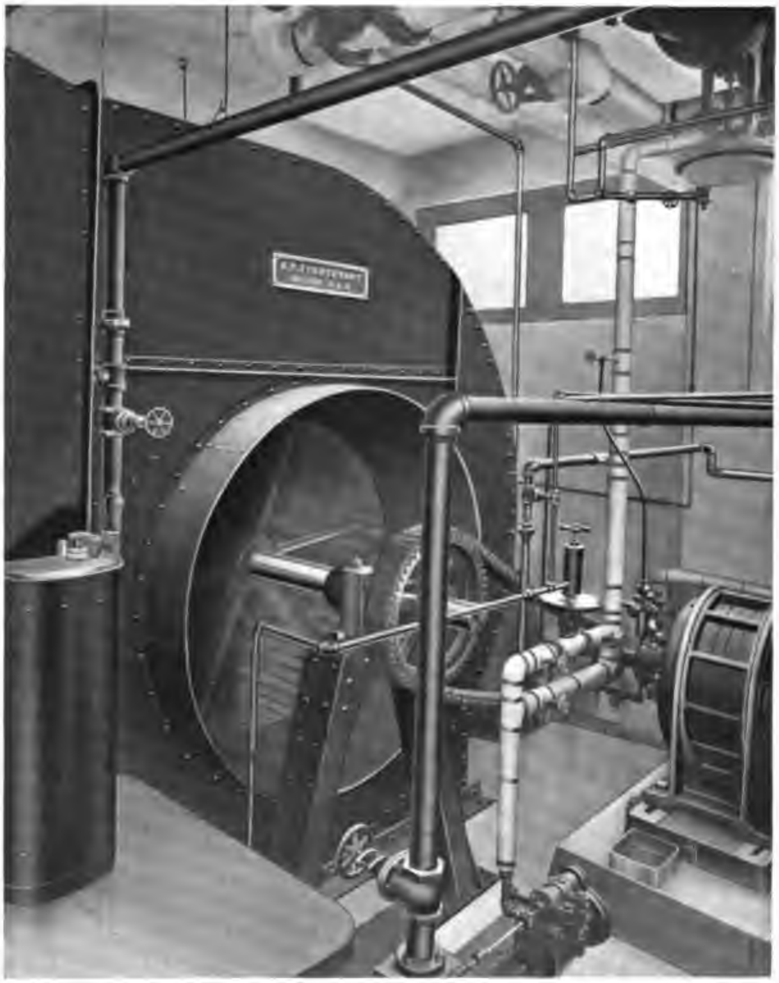

FIG. 4. STURTEVANT HEATING APPARATUS, BROWN-LIPE-CHAPIN CO., SYRACUSE, N. Y.

this. The air washer is the only practical means for increasing the amount of moisture in the air, and the heating systems of buildings without ventilating fans are therefore seriously handicapped, owing to the inability of installing an air washer where no fans are used and where the outside air is allowed to enter the building through many and uncontrolled entrances.

15. Explanation of Tables Nos. 1 and 21

In Table No. 1 are shown the relations existing between the weights of air and vapor, in saturated mixtures and at different temperatures. This table will be found exceedingly useful in all calculations relating to heating and drying. Part of the information tabulated here is graphically set forth in the chart of Fig. 3.

Table No. 21 has been prepared from the psychrometric tables published by the United States Department of Agriculture, Weather Bureau. This table is arranged to show the relative humidity, the absolute humidity and the dew point for various temperatures of the dry bulb thermometer of the hygrometer with various differences between dry and wet bulb temperatures. The table also includes the weight of a cubic foot of saturated air and the absolute humidity or grains of moisture at saturation point for various temperatures.

16. The Specific Heat of Air

The specific heat of air is the ratio of the heat necessary to raise a given amount of air through a degree of temperature to the heat necessary to raise the same amount of water from the temperature of maximum density, 39.1, through the same range of temperature. There is considerable disagreement among authorities as to the specific heat of air, various experimenters having determined values. For calculating the tables in this book, a specific heat of .2379 has been used. This is according to Regnault's experiments, and is known as the specific heat of air at constant pressure.

For calculation in heating and ventilating work, the specific heat of air at constant pressure is usually taken as .25, this being a close enough approximation when the large percentage of error due to the innumerable conditions affecting the heating problem is considered.

17. Diffusion

Unlike liquids, gases which have no chemical effect upon one another will not separate according to their relative specific gravities or densities but will mingle with each other to form one uniform mixture. Such a phenomenon is called diffusion. Perfect diffusion of gases of different temperatures and densities is not instantaneous, the time required varying inversely as the density and directly as the square root of the absolute temperature.

Air as a mixture, however, seeks different levels, according to its relative temperature. The influence of objects relatively hotter or colder than the air itself therefore may be employed as an aid to ventilation. Thus the cold area of glass in a window causes a downward current of air in its vicinity, while the heat evolved from the human body gives rise to a general upward movement of air.

Because of this phenomenon of diffusion, it is impossible to control absolutely the removal of vitiated air from occupied rooms and ventilation becomes a matter of air dilution. The fresh air supplied for ventilation is diffused more or less rapidly throughout the apartment and it is only by maintaining systematic air currents and controlling their direction that the air can be removed as soon as it becomes vitiated.

CHAPTER II

VENTILATION

18. Necessity of Ventilation

THE necessity of supplying sufficient air that is pure and healthful in places where people are crowded together in rooms, halls or shops, is appreciated more every day. The evil effects of air that is vitiated by the occupants of a room have been carefully studied by investigators with a view to making perfect ventilation possible, or the realization of ideal exterior air conditions inside. When it is considered that, without air, no life can exist and that it is impossible to maintain life with the air supply cut off even for extremely short periods, it can well be imagined what a serious effect the pollution of air may have upon comfort and health.

The beneficial effects of proper ventilation are made evident by such facts as " death rates have been reduced by the introduction of efficient ventilating systems in childrens' hospitals from 50 per cent. to 5 per cent.; in surgical wards of general hospitals from 44 to 13 per cent.; in army hospitals from 23 per cent. to 6 per cent." *

Statistics show that the lack of ventilation in schools is the direct and indirect cause of tuberculosis. The number of pupils succumbing to this disease contracted in our public schools is appalling. In trades, the evil effects of insufficient ventilation are especially alarming, because a lack of good air in such places is often coupled with unsanitary plumbing, or injurious dust and fumes, conditions that are serious enough in themselves to be dangerous.

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* Notes on H. and V., Prof. S. H. Woodbridge, M. I. T., Boston.

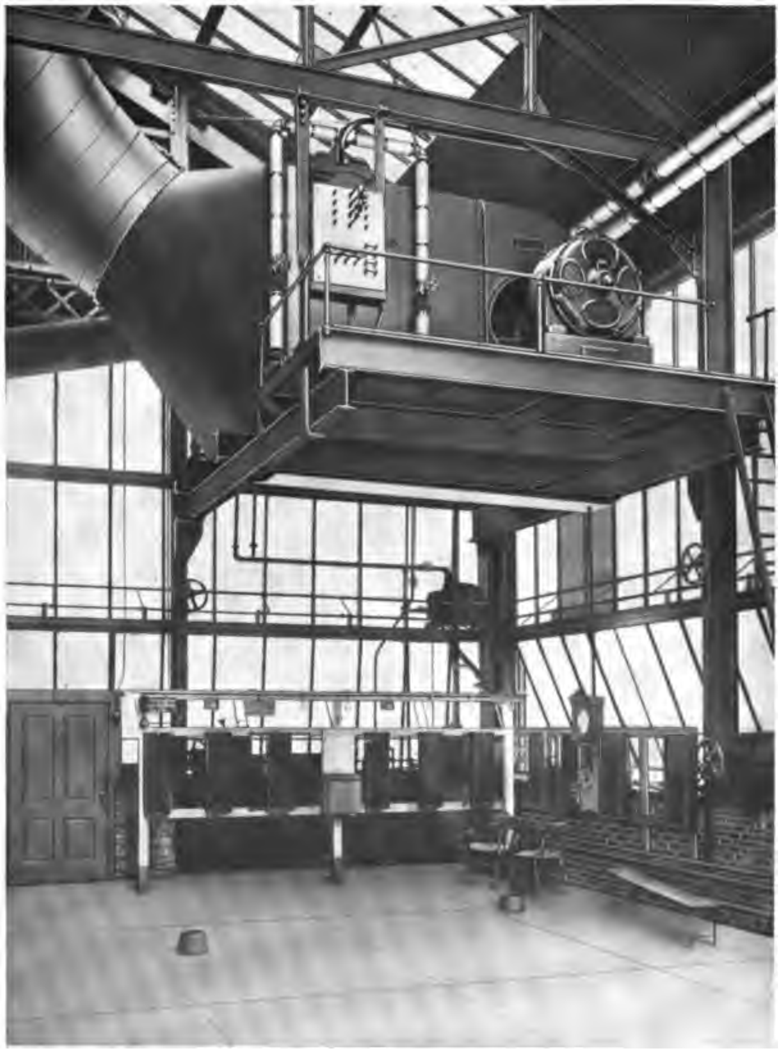


FIG. 5. HEATING APPARATUS ON SUSPENDED PLATFORM.

Dr. George Webster, M.A., in an address before the Chicago Medical Society, divided occupational diseases into five classes.

1. Those due to gases, vapors and high temperature.
2. Those due to increased or decreased atmospheric pressure.
3. Those due to metallic poison, dust or fumes.
4. Those due to organic or inorganic dust and heated atmosphere.
5. Those due to fatigue.

It is evident that impure air is playing the important part in occupational diseases as indicated in the above classification. It is to relieve conditions that are unhealthful and cause disease among employees that ventilation is resorted to. While it is, of course, impossible to create ideal conditions, nevertheless, it is possible to ameliorate those already existing and thereby to combat the greatest plague of the modern workingman's life, — Consumption. It will be noted in the above classification that three classes of disease are due to causes which can be greatly affected by good ventilation, the first, the third and the fourth. Wherever dust, gases, vapors or fumes are causing disease, ventilation will protect the workingman, and wherever heat is so excessive that it is dangerous to health, it is usually possible to reduce the temperature to normal.

It is not only in these most serious and more apparent consequences alone that the evil effects of impure air are revealed. A vitiated atmosphere lowers the vitality, increases the susceptibility to and severity of disease and decreases the physical and mental working power of the individual and, while not directly producing immediate death, nevertheless inevitably shortens life.

Good ventilation is, moreover, a factor for industrial efficiency, and as a prevention for disease and consequent loss to the employer, a well-designed system of ventilation more than warrants the investment it necessitates. It becomes an insurance against sickness and inefficiency.

19. Causes of Vitiation

Since the vitiation of the atmosphere produces the necessity of providing ventilation, the causes of vitiation must be known in order to plan a ventilating system intelligently.

Air is made impure by respiration. The air of the room, taken into the lungs containing 4 parts of CO_2 (carbon dioxide) in 10,000 of air, is respired with a proportion of 400 parts of CO_2 in 10,000 of air. Thus, in a room where no ventilation or change of air is provided, and which is occupied by many people, the percentage of CO_2 soon becomes abnormal and the atmosphere is said to be vitiated. The ensuing effects are headaches, faintness and a feeling of general discomfort among the occupants. Long continuation in such an atmosphere produces drowsiness which may take the form of asphyxiation if relief is not forthcoming.

As previously stated in Section 8, Chapter I, it is not the CO_2 itself that is so dangerous and unhealthful, but the attendant constituents of respired air and, as CO_2 is most easily measured, it furnishes an index for comparison with pure air standards. These other impurities, micro-organisms and disease germs, are in the breath, and are admitted to the atmosphere by the evaporation of moisture from the throat and lungs and by emanations from the skin.

20. Composition of Respired Air

Carpenter * gives the following table indicating the composition of air entering and leaving the lungs and the approximate relative volumes of its chief constituents.

		ENTERING	LEAVING
Oxygen	(per cent. of volume) . .	20.26	16
Nitrogen	(" " " ") . .	78.00	75
Water Vapor	(" " " ") . .	1.70	5
Carbon Dioxide	(" " " ") . .	0.04	4

* A Treatise on Heating and Ventilating Buildings.

21. Vitiation due to Gas Burners

A single gas burner has the effect of vitiating the same amount of air as three, four or five persons, and is, therefore, a factor to be considered in the design of a ventilating system. The oxygen of the air is necessary for the combustion of the illuminating gas. Combustion is accompanied by the production of heat and CO_2, while the available supply of oxygen is materially lessened, thus lowering the value of the air for breathing purposes. Besides the emission of CO_2 as a product of combustion, there are apt to be other and more harmful gases aiding the vitiation. Moreover, the quantity of heat evolved is often sufficient to warrant a frequent purging of the room with fresh air, a condition which argues strongly for the ventilation system.

22. Manufacturing Conditions

In the trades, conditions exist that easily vitiate air, such as processes involving the creation of dust, or the emission of smoke and fumes into the air of the room. It has been but recently that an effort has been made to regulate such conditions. The investigations of state inspectors have proved only too well the deplorable sanitary conditions in factories and workrooms. The failure to supply proper ventilation to militate against the infectious diseases so prevalent among workmen in shops can be due to no reason save that of ignorance on the part of the factory owner in regard to the economic value of pure air. Those whose progressiveness in matters of this sort have led them to experiment, have proved that, disregarding humanitarian considerations entirely, the installation of a positive system of ventilation in their shops has been an investment from which the returns have more than warranted the original outlay in that there is an increased effectiveness in the workmen laboring under ideal sanitary conditions and a decreased susceptibility to illness with its attendant loss both to employer and to employee.

Report of Commissioner of Labor John Williams for Factories in New York State, 1908

Type of Building	Number Investigated	CO_2		Outside Temp.		Remarks
		Highest	Lowest	High	Low	
Cigar factory	28	80	8	71	47	With windows partly opened, lowest per cent. CO_2, with windows all open.
Clothing industry establishments	21	42	9	73	40	Lowest, with nearly all windows open.
Hat factory	337	30	7	78	54	Inspection rooms, windows and doors open and fan in one room. Much gas used for lighting, heating and blocking.
Laundry	19	22	11	79	65	Worst trouble from gas irons. Windows and door open, some ventilating fans
Paper box factories	3	22	11	74	72	All windows and doors open, gas used to heat glue.
Printing rooms	55	40	7	82	39	179 tests made. Natural and artificial means of ventilation resorted to.

23. Report of Commissioner of Labor John Williams for Factories in New York State, 1908

The findings of the Commissioner of Labor for New York State briefly summarized in the accompanying table indicate the conditions under which the laboring population is forced to work. It is for the improvement of these unsanitary conditions that laws must sooner or later be framed and enforced throughout the entire United States. It is, as a rule, not through lack of humanitarian interest among employers that such conditions exist, but through ignorance of how these conditions may be relieved or improved. It is one of the objects of this book to supply, in a general way, a clear understanding of the principles involved in the heating and ventilating of buildings of all types so that the layman may have a more accurate knowledge of the means by which ventilation may be satisfactorily accomplished.

24. Amount of Air Required for Ventilation

Under the general conditions of outdoor air, namely, 70 degrees temperature and 70 per cent. of complete saturation, an average adult man, when sitting at rest in an audience, takes 16 respirations per minute of 30 cubic inches each, or 480 cubic inches per minute. The air thus inhaled will consist of about one-fifth oxygen and four-fifths nitrogen, together with about .17 per cent. aqueous vapor and .04 per cent. carbon dioxide. By the process of respiration air, when exhaled, will be found to have lost about one-fifth of its oxygen by the formation of carbon dioxide, which will have increased about one hundredfold, thus forming about 4 per cent., while the water vapor will form about 5 per cent. of the volume.

In addition, the inhaled air will have been warmed from 70 degrees to 90 degrees and, notwithstanding the increased proportion of carbon dioxide, which is about one and one-half times heavier than air, will, owing to the increase of temperature and

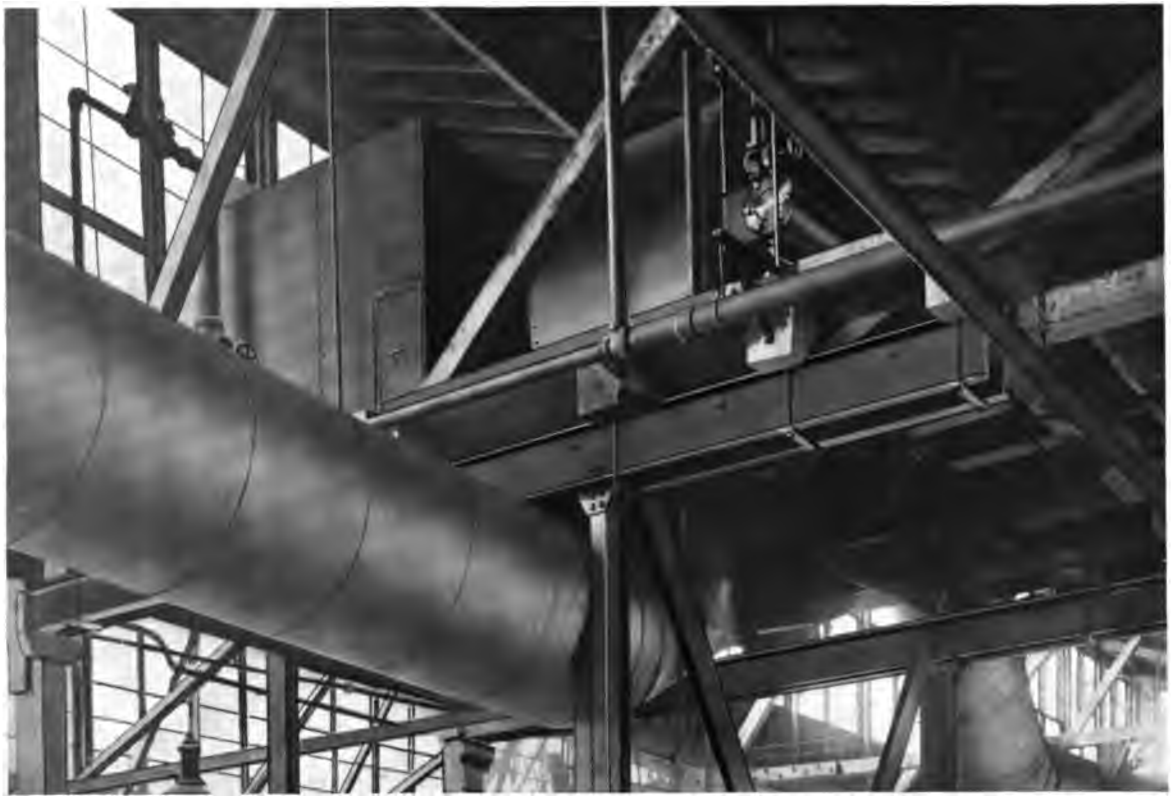


FIG. 6. STURTEVANT HEATING APPARATUS INSTALLED OVERHEAD. KUHLMAN CAR CO.

the levity of the water vapor, be about 3 per cent. lighter than when inhaled. Thus it will be seen that this vitiated air will not fall to the ground, as has often been presumed, but will naturally rise above the level of the breathing line, and the carbon dioxide will immediately diffuse itself into the surrounding air.

In addition to the carbon dioxide exhaled in the process of respiration, a small amount is given off by the skin. Furthermore, 1½ to 2½ pounds of water are evaporated daily from the surface of the skin of a person at rest. If the air supply at 70 degrees is assumed to have a humidity of 70 per cent. and to be saturated when it leaves the body at a higher temperature, then at least 4 cubic feet of air per minute will be required to carry away this vapor.

Taking into consideration these various factors, it is found that at least 4½ cubic feet of fresh air will be required per minute for respiration and for the absorption of moisture and dilution of carbon dioxide gas from the skin. This, however, is only on the assumption that any given quantity of air, having fulfilled its office, is immediately removed without contamination of the surrounding atmosphere. This condition is impossible, for the spent air from the lungs, containing about 400 parts of carbon dioxide in 10,000 of air, is immediately diffused in the atmosphere. The carbon dioxide does not fall to the floor as a separate gas, but is intimately mixed with the air and equally distributed throughout the apartment. A considerably greater amount of air is therefore necessary.

The table of Section 26, Chapter II, shows the amount of air to be supplied per person for various degrees of vitiation maintained within the room. The table of Section 102, Chapter VI, shows the amounts of air usually provided in various types of buildings.

25. Standards of Ventilation

There are so many different causes for a vitiated atmosphere that there are many standards by which proper ventilation should be judged and the amount of ventilation figured. Ventilation, according to the Sturtevant System, deals not only with the physical but with the physiological properties of the atmosphere as well, which makes it possible to heat and cool, to remove dust and impurities and to regulate the relative humidity of the air.

It may be readily seen that while the air supplied to an apartment may be perfectly satisfactory according to certain standards, it may be entirely unfit for breathing purposes when judged by other standards. Hence it is necessary when planning a ventilating system that all the possible conditions affecting the air supply or the nature of the supply be considered carefully and understood intelligently.

26. CO_2 Standard

The oldest and most generally accepted standard of ventilation is the CO_2 standard in which the necessary amount of air for ventilation in an apartment is figured from a knowledge of the amount of CO_2 probably admitted into a room by its occupants, and the permissible amount that may exist in the air in the room. The amount of CO_2 in the room is easily measured and, as previously stated in Section 8, Chapter I, gives a method by which the degree of vitiation of the atmosphere may be calculated.

For the purpose of calculating the amount of air required for ventilation by knowing the degree of vitiation of the air in the room as expressed in parts of carbon dioxide in 10,000 parts of air, the following method is employed. Six-tenths cubic feet per hour is generally accepted as the average production of carbon dioxide by an adult at rest, and the proportion of this gas existing in external atmosphere as 4 parts in 10,000. If, therefore, the degree of vitiation of the occupied room be maintained at 6 parts of carbon dioxide in 10,000, there will be permissible an increment of .0002 of a cubic foot of carbon dioxide in each

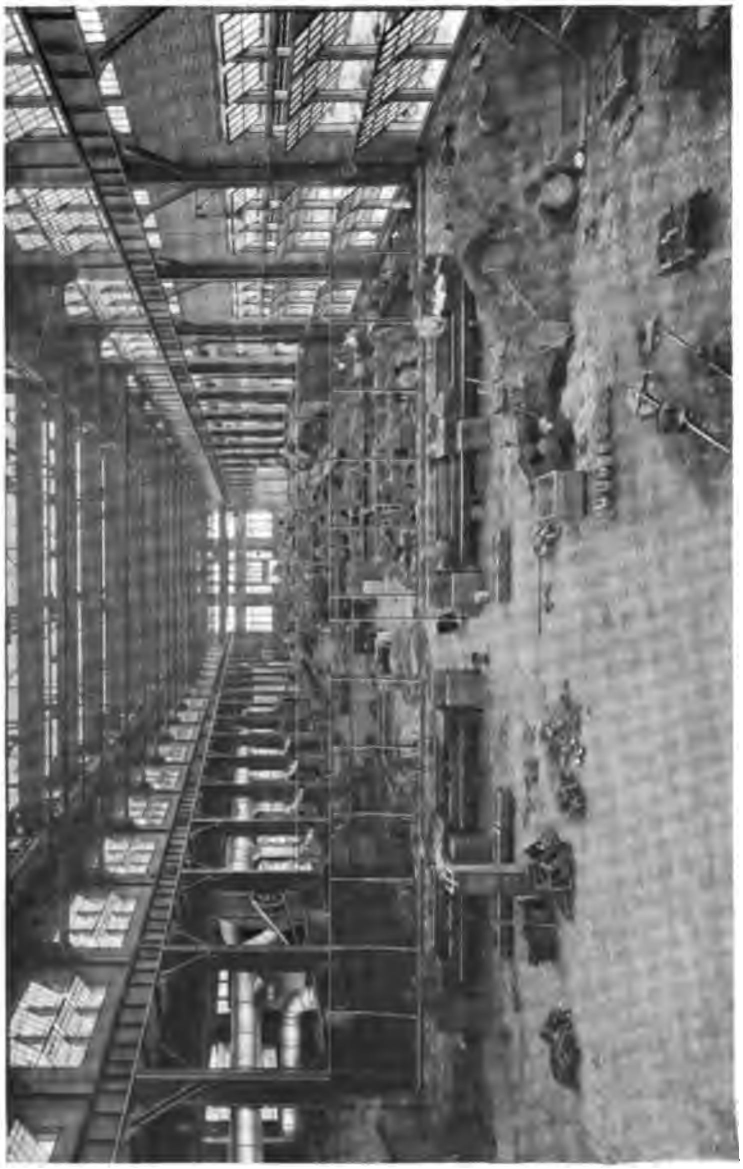


Fig. 7. Sturtevant Heating Apparatus in Iron and Brass Foundry. L. & N. R. R. Shops, South Louisville, Ky.

Cubic feet of air containing 4 parts of Carbon Dioxide in 10,000 supplied per person.	Per Hour	6,000	4,000	3,000	2,400
	Per Minute	100	66.6	50	40
Degree of Vitiation of the air of a room.	Parts of CO_2 in 10,000	5	5.5	6	6.5

cubic foot of air. The .6 cubic foot of carbon dioxide produced per hour by an individual will therefore require for its dilution to this degree .6 divided by .0002, or 3,000 cubic feet of air per hour. The above table has been calculated on this basis. Besides the carbon dioxide produced by the occupants of the room, allowance must be made for that produced by the gas burners, if the room is lighted in this manner. (See Section 21, Chapter II.)

27. Temperature Standard

If the temperature of air in an apartment reaches a certain point, the respired air will cease to rise and, instead, will remain at a lower level where it is breathed again by the occupants. Also the air immediately surrounding the body, being vitiated by emanations from the body, will not rise, owing to the excessive temperature of the room, and unless there are currents of air in the room, this vitiated envelope will be dissipated only slowly.

In theatres and audience halls especially, there is so much heat generated by the occupants that the temperature of the building becomes excessively high. It then becomes the function of the ventilating system to purge the building of the heated air, introducing in its place fresh air at a lower temperature. In printing shops, glass factories and numerous other buildings where the heat becomes excessive, the temperature standard of ventilation becomes of utmost importance, for while such problems may be considered as relating more to cooling than to ventilation, yet ventilation is the object sought for as much as cool-

2,000	1,800	1,714	1,500	1,200	1,000	545	375	231
33.3	30	28.6	25	20	16.6	9.1	6.2	3.8
7	7.33	7.5	8	9	10	15	20	30

ing. The subject of cooling by ventilation is considered in Section 49, Chapter III.

Recent investigation tends to show that a movement of air in the room, slight enough so that it is not annoying as a draft yet strong enough to change the envelope of air around the body continuously, is beneficial and a solution to many heretofore perplexing ventilation problems. In the light of this, the location of registers, both inlet and outlet, takes on an added significance and importance, for here is the secret of proper air distribution.

28. Dust Standard

In manufacturing establishments and in buildings in large cities, dust is one of the factors which determines a good ventilating system. In many manufacturing places, the dust emitted is extremely harmful and sometimes of a poisonous nature. Sufficient air should be supplied and removed from rooms filled with dust of this sort to clear the atmosphere. In the case of machines that produce dust, hoods connected with ventilating fans should be used in order to protect the operator from the dangers of this dust. In shipping and receiving rooms there is often considerable dust due to the opening of shipments. Ventilating fans will do much toward clearing the atmosphere in such places as these. The air of the foundry may be easily cleared of both smoke fumes and dust by a carefully designed ventilating system. Kitchens and smoking rooms come into this class of rooms in which the removal of local impurities is one of the most important phases of a ventilating problem. In Chapter VIII these subjects are more fully discussed.

29. Micro-organism Standard

Although a knowledge of the exact character of the micro-organisms in vitiated air and their effect upon the human system is very meagre, such organisms are known to exist and it is safe to assume that they are undesirable and probably injurious. Certain germs of throat and lung diseases are easily transmissible from one person to another in a vitiated atmosphere, and, on this account, an abundant supply of fresh air is necessary wherever a number of people are occupying the same room for any length of time. These germs, exhaled from the throat or emanated from the body, should be carried away by the general flow of air through the room. One of the most important functions of a ventilating system in theatres, court-rooms, schools and similar places is to clear the rooms by continuously flushing the impurities from them by means of large quantities of fresh air.

30. Humidity Standard

Personal comfort is affected very materially by the relative humidity of the air supplied for ventilation purposes. In Section 10, Chapter I, we have spoken of relative humidity and its effects. A ventilating system should control in some way the relative humidity of the air which it supplies to the building. In cold weather, as pointed out in Section 14, Chapter I, the actual humidity of the air is very low although the relative humidity may be normal. Upon being heated, the relative humidity falls rapidly so that unless moisture is added the air will be delivered to the rooms in too dry a state. Not only does this affect personal comfort, but in many cases may be injurious to the woodwork and furnishings of the room, causing the evaporation of too much moisture from them. On the other hand, the room maintained at the proper temperature and supplied with fresh air may seem uncomfortable to the occupants because the relative humidity is too high. In manufacturing places, where considerable moisture is admitted to the air, provision should be made in the ventilation system for supplying enough air to absorb this moisture. This problem is considered in subsequent sections of the book.

31. Methods of Ventilating

In order to ventilate a building, or a room in a building, three methods at once present themselves.

1. *Natural Methods,* in which open windows, ventilating flues or chimneys are resorted to as a means of bringing fresh air into a room or removing stale air from the room.
2. *Ventilation by Aspiration,* in which the natural draft of a flue or chimney is augmented by a heater.
3. *Ventilation by a Forced Circulation of Air,* in which a fan is employed to supply air to, or remove it from, a building or a room, known as *Mechanical Ventilation.*

32. Natural Ventilation

The simplest and most ineffective and unreliable method of ventilation is to resort to natural means, such as open windows and the unaided effect of flues or chimneys. Such methods cost nothing to operate, but neither do they accomplish the desired result since they are dependent upon weather and atmospheric conditions. Open windows create drafts and must be closed in cold or wet weather. Vent flues and chimneys are dependent upon winds and climatic conditions for their operation as are also automatic ventilators made to be placed in windows or skylights. Natural methods, as a rule, can be successfully applied only to such buildings as open air schools, or hospitals where the occupants of the rooms are dressed for outside weather conditions, or to buildings where the occupations of the tenants are not interfered with by cold, dampness or drafts.

33. Ventilation by Aspiration

By warming the air in vent flues, an upward current is produced that has a slight effect in ventilating an apartment. The influence of the temperature of air upon the conditions of its movement will be found in tabulated form in Table No. 3. Gas jets and steam heated surfaces placed in vent flues and smoke flues from steam or hot air furnaces are often employed for this purpose. However, the heat so used serves no useful purpose other than that of creating an upward movement of air and is lost to the outside atmosphere. The method is therefore expensive of power as measured in heat units, and is not to be recommended as being efficient. Gas jets are often placed in the ceilings of audience halls to induce a flow of air from the hall, but such a method is incapable of removing sufficient air to provide necessary ventilation and is as uneconomical as though the gas jets were placed in flues. The method is, moreover, more or less dependent upon climatic conditions and is by no means positive in operation. At best it should be resorted to only as supplementary to a more efficient system or as a makeshift where no other means is available.

34. Forced Ventilation

To even the layman, the superiority of forced ventilation by means of that universally adopted machine, the fan, needs no proof. Experience has shown it to be not only superior to the methods of ventilation mentioned in the foregoing paragraphs but the only positive means that is at once efficient, practical, independent of climatic conditions and susceptible of control. To accomplish ventilation by forced circulation it is arranged either to exhaust air from the building or to force air into it, and, under certain conditions, a combination of the two is used. In any case, the fan is used as being the source of the most efficient aeromotive force.

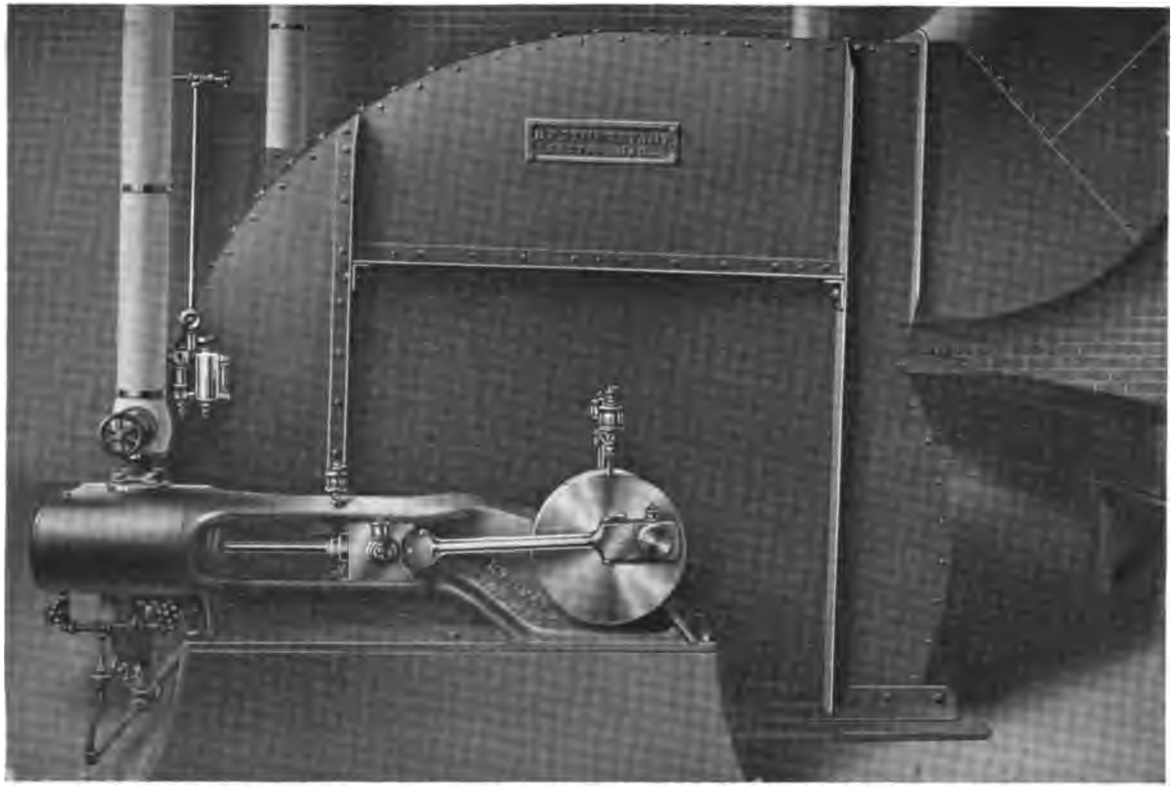


FIG. 8. STURTEVANT HEATING APPARATUS. KUHLMAN CAR CO.

35. The Exhaust Method

When air is drawn from the room by the action of the fan, it is said to be exhausted. Exhaust methods, as a rule, provide no means for the entrance of air into the room, the air being allowed to flow in through suitable openings or to leak in through windows, doors or cracks. A very slight vacuum is established within the apartment by the action of the fan drawing air from it, and, on this account, leakage into the room takes place wherever there is an opening. In cold weather this is apt to give rise to drafts and, on this account, the exhaust method is rarely resorted to as the only means of ventilating an apartment unless provision can be made for heating the air as it passes into the room.

There are various problems of ventilation that can be handled best by exhausting, such as the ventilation of toilets, kitchens and rooms where it is necessary to remove odors, smoke, fumes, dust or gases. These, however, are special problems, and are discussed in another section. For general ventilation of occupied rooms, the exhaust method is used only when the air supply can be heated as mentioned above, or in conjunction with a plenum or positive supply system.

36. The Plenum Method

Ventilation by the plenum method is accomplished by forcing air into the apartment to be ventilated. The fan is universally used as the means for establishing this plenum condition. It will be seen that this method is positive in supplying air and in supplying it continuously. A slight pressure is maintained within the ventilated apartment so that any leakage is naturally outward, thus eliminating drafts from outside. Furthermore, the point of admission is under complete control, and, as will be pointed out later, opportunity is thus given for regulating the volume as well as the purity and temperature of the entering air. There is, therefore, no opportunity for polluted air to be drawn into the room from any external source, since all the air is admitted through this one inlet, and since the tendency of the air is to blow outward and not inward. The escape of the air from the room is generally accomplished through the walls, cracks, windows and doors, or through vent flues especially built for this purpose as employed in school houses and theatres and as explained more fully later.

37. Combined Plenum and Exhaust Methods

Where it is desired that ventilation shall be especially thorough, there is often a combination made of the plenum and exhaust methods. This arrangement provides a mechanical and positive means of introducing fresh air into the apartment to be ventilated and a distinctly separate apparatus for the removal of the air that has become vitiated. A positive circulation of air is set up and maintained throughout the apartment, causing a continuous flushing and providing the most effective means of ventilation that it is possible to obtain by mechanical means. The system well might be called balanced, as the pressure is equalized and the opening of windows, where such a system is provided, should not be necessary or interfere with its satisfactory operation. This system is often necessary where the complicated arrangement of vent flues makes it impossible to obtain any natural draft for removing the vitiated air. There are, moreover, certain types of rooms and buildings where this system is almost universally employed. Theatres are usually ventilated in this manner and kitchens, restaurants, smoking rooms and other places where there is some agency of vitiation other than the respiration of the occupants. This system is practically a necessity if good ventilation is to be realized and is the most perfect system that can be devised. In proof of this fact, are the numberless installations made nowadays in which this double system of combined plenum and exhaust apparatus is used.

38. Humidifying and Air Washing

Although accomplished by the same apparatus, air washing and humidification should not be confused as being the same. They differ widely. The object of humidifying, as already pointed out in Section 14, Chapter I, and Section 30, Chapter II, is to regulate and control the relative moisture content of the air, while the air washing deals only with the cleansing of the air from dust and soluble impurities. Related as they are by the common apparatus used to accomplish the desired results, it is logical that they should be considered at the same time. The subject of air washing is taken up in the following section, and in another section (84 to 94 of Chapter V) will be found a careful consideration of the various types of apparatus designed to accomplish this result.

39. The Use of Air Washers

Air washing becomes a desirable feature in connection with the ventilation of buildings in cities. Dust from the street, smoke and local impurities in the air are in such abundance in congested districts that they may become harmful agents when introduced in buildings. With natural methods of ventilation all the dust from the street is carried into the building through open windows. The air washer used in connection with the Sturtevant System creates a miniature rain storm which cleans the air of the dust and soluble impurities so that it enters the rooms pure and fresh.

Besides the advantage of better air for breathing purposes, thoroughly cleaned air lengthens the life of the interior decorations of a building. Where air washers are used, no dust or dirt from the street is allowed to enter the rooms to settle on furniture, walls and decorations, making the ceilings and walls dingy.

There are, moreover, manufacturing concerns, the character of whose product is such that clean, dustless air of proper humidity is necessary for the finest finished product. In order to secure this atmosphere, windows must be tightly closed and mechanical ventilation used. The air washer then becomes a valuable business asset and appeals to the prospective owner upon grounds of greater commercial economy.

In another section will be found a reference to the use of air washers in textile mills where they are necessary as humidifiers to maintain the moisture content of the air at the desired amount.

The use of air washers for cooling is considered in Section 14, Chapter I, and Section 50, Chapter III.

CHAPTER III

HEAT, HEATING AND COOLING

40. Relation of Heat to Life

ALL life is accompanied by the generation of heat by the combustion of organic tissues in the presence of oxygen. The process is analogous to the combustion of coal in a furnace, in either case the process being one of oxydation.

Air entering the lungs comes in contact with the blood from the heart, is absorbed by the hæmoglobin of the blood and is carried with it to all parts of the body where the combustion of organic tissues takes place, accompanied by the generation of heat and carbon dioxide. The carbon dioxide is carried back to the lungs in the blood, where it is expelled in the process of respiration.

The normal bodily temperature of man is about 98.6 degrees Fahrenheit. Variation of sufficient magnitude either above or below this temperature will prove fatal. There is, therefore, a temperature at which the functions of life are carried on with the least effort and strain upon the vitality of the individual. Without heat, life is impossible, yet this heat cannot be supplied from without, the only function of external warming being the reduction of the rapidity with which bodily heat is dissipated.

41. Heat of the Body

The heat generated by the human body varies with the age of the individual, his activity and the temperature of the surroundings. This heat is lost to the outside air to the extent of about 400 B. T. U. per hour, more or less, by an adult, while a

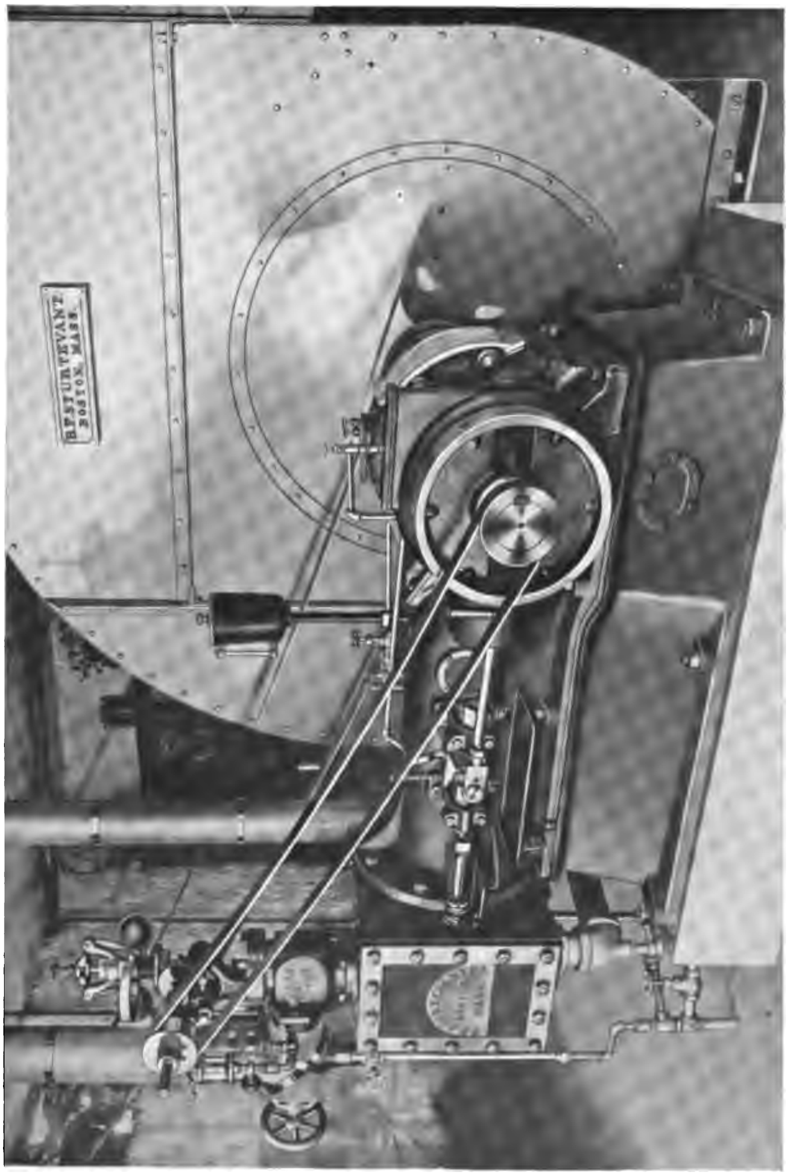


FIG. 9. STURTEVANT FAN AND LOW PRESSURE ENGINE. GARRISON SCHOOL, ROCKFORD, ILL.

child gives about half of this amount. Approximate figures as to the relative amounts lost by various means are:

30 per cent. lost by contact with the air,
43 " " " " radiation,
27 " " " " exhalation and other losses.

In large halls, theatres, churches and crowded workshops and mills, the amount of heating accomplished by the animal heat of the occupants of a room is worthy of being considered, less heating being necessary in such buildings; in fact, it is usually desirable and necessary to remove this heat by a continual flushing of the room with ventilating air. Heat alone in crowded rooms is responsible for much discomfort generally attributed to bad air.

42. Means of Dispersion of Heat

Three methods are provided for the healthful dispersion of heat from the human body. *First*, by radiation to the air and surrounding objects. *Second*, by conduction, principally to the air immediately in contact with the body. *Third*, by evaporation of moisture from the lungs, throat and skin. With air conditions as they generally exist externally in summer, the last two are generally about equal, but the greater part of the heat is dissipated by the first means. Air is a nearly perfect non-conductor of heat, but radiation takes place through it readily. We may enter a room having a temperature of 75 degrees with walls at 50 degrees and feel chilled, simply because heat is rapidly radiated from the body through the air to the colder walls. In comparatively dry air, equality of temperature is maintained by a steady but imperceptible evaporation from the skin. In moist air, this rapid evaporation is prevented and moisture is deposited as perspiration, the air being too heavily moisture-laden to take it up. On the other hand, when the air is in motion it increases both evaporation and conduction by the constant supply of fresh air to take the place of that already moisture-laden or heated. If, under any circumstances, one of these three means fails to abstract heat rapidly enough, the removal by the other means is increased and equilibrium of temperature maintained.

High humidity has the effect of modifying very materially the temperature at which comfort may be secured. The excessive humidity of the atmosphere of the west and south of England, causing a reduced rate of evaporation from the body, has the effect of making comparatively low temperature in that country equally as comfortable as a much higher temperature in the dryer climate of Canada or Minnesota.

43. Air Currents

The heat given off by the body gives rise to upward currents of air owing to the natural levity of heated air. These air circuits create a natural means of ridding the body of the envelope of bad air which forms around it. As stated before, this air immediately surrounding the body is vitiated not only by the breath but by emanations from the skin and by the evaporation of the moisture of the body from mouth, throat and skin. The temperature of the body is normally about 98.6 degrees Fahrenheit. If the temperature of the surrounding air is 70 degrees or over, there is not enough difference in the levity of the vitiated air surrounding the body and that of the air of the room for the body to rid itself automatically of this vitiated envelope. This, however, may be overcome by lowering the temperature of the room to, say, 65 degrees. Although the air of the room may be pure enough for breathing purposes, a temperature of 70 degrees or over is apt to give the discomfort usually attributed to badly vitiated air, while, other conditions the same, a room at a temperature of 65 degrees would be considered well ventilated.

The value of drafts in rooms that are apt to be overheated by crowding is easily realized in this connection, since any movement of air aids in dispersing this envelope of air from the body and in replacing it by fresh, unvitiated air. A movement of air across the body also increases the rate of evaporation of moisture from the skin and has considerable cooling effect.

44. Temperature in Heating

The proper temperature at which a room should be maintained and the effect of varying this temperature is worthy of considerable attention, as it is doubtlessly true that many of the complaints heard against ventilation systems are due to improper temperature regulation.

In this country, for ordinary heating installations, 70 degrees has been the guaranteed room temperature. Under the best conditions of humidity and purity of atmosphere, this may not be too high. The tendency is, however, to maintain a lower temperature than 70 degrees, especially in schools, halls, offices and similar places.

The Chicago Ventilation Commission has adopted 68 degrees " with proper relative humidity " as the proper maximum temperature for artificially heated apartments. In a paper read before a Congress for heating and lighting, Schumaker of Berlin stated that the temperature of class rooms should be 64.4 degrees at the height of the head, while temperatures below 60.8 degrees or above 68 degrees should be avoided.

Dr. W. A. Evans, M.D., suggests that where air is free from noticeable currents, the temperature should not be over 65 degrees. Where there is a slight movement of air, enough so that the change of the air envelope about the body is noticeable, 68 to 70 degrees is a temperature that may be maintained without discomfort to the occupants of the room, but where a temperature of 70 degrees is to be maintained, a breeze of not less than 10 miles per hour is necessary for physical comfort.

Prof. C. E. Winslow, Assistant Professor of Biology, College of the City of New York, complains of a temperature of over

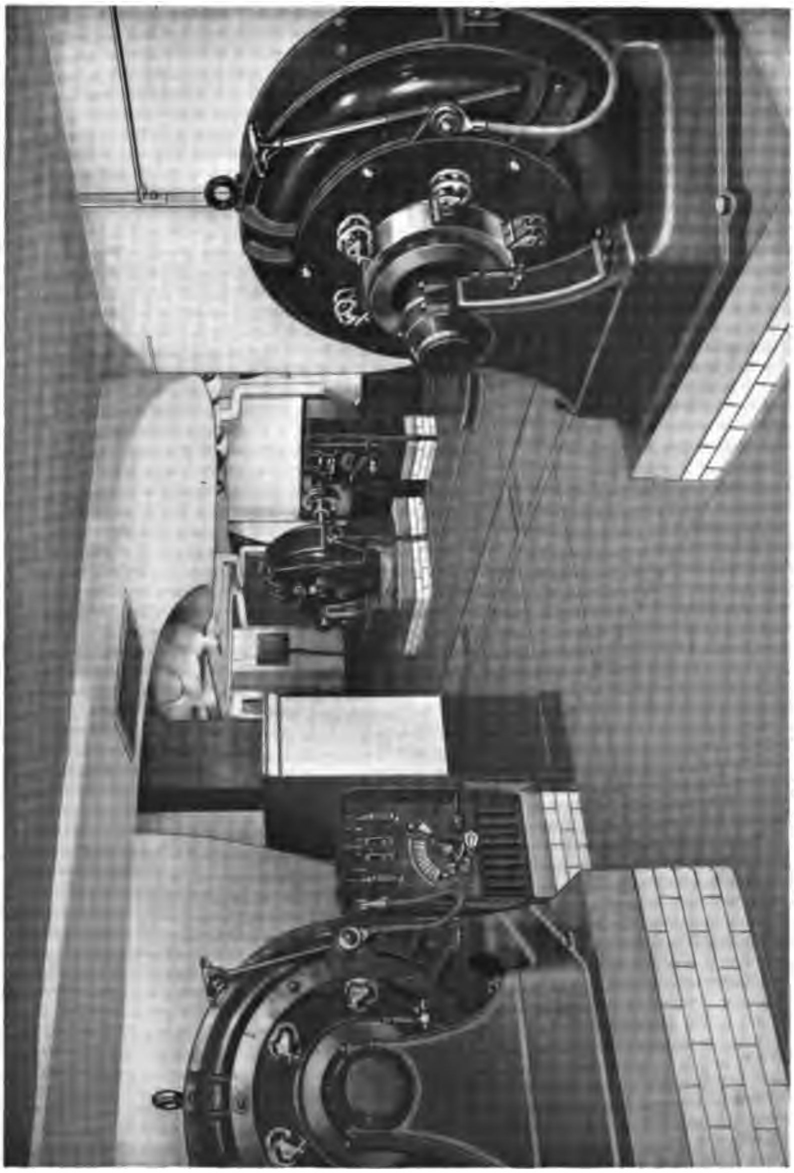


FIG. 10. STURTEVANT VENTILATING APPARATUS. NEW YORK STOCK EXCHANGE.

70 degrees as being " distinctly harmful," while Dr. C. Ward Compton, Director of Physical Training, New York City Department of Education, gives the proper temperature in schools as 65 to 68 degrees.

In factories, foundries, forge-shops, publishing rooms and those manufactories where the operations carried on are attended with the generation of heat in furnaces or stoves, the temperature should be kept considerably lower. Where men are engaged in strenuous manual labor, a temperature of 70 degrees is much too high for comfort, 60 to 65 degrees, or even lower, depending upon the conditions and upon the nature of the labor, being more to be desired.

Owing to the fact that those occupying churches and other halls are generally in street costume, and that the great number of people as compared with the space occupied is the cause of rapid heating of the building due to the natural heat of the body, a temperature of 60 degrees is not too noticeably cool. A few minutes' occupancy will suffice to bring the temperature up to where there is little further necessity of heating artificially.

45. Object of Heating

The primary object of heating is not, as may be popularly supposed, the heating of the body itself, but the prevention of too rapid loss of heat from the body to outside air and to exterior objects by air contact, radiation and evaporation. The object of cooling, on the other hand, is to increase the rate of loss of heat which is decreased by a too high room or atmospheric temperature.

The object of heating is, therefore, to maintain such a temperature as will permit of a normal rate of loss of heat. To increase the rate of loss by lowering the temperature is a tax on the vitality that may be carried to a dangerous degree; to decrease the rate of loss creates an abnormal physical condition, equally dangerous.

46. Methods of Heating

The heating of modern buildings is generally accomplished by direct radiation, indirect radiation, indirect-direct radiation or by hot blast. With direct radiation, a radiator, using as a heating medium either hot water or steam, heats the apartments by the direct radiation of the heat it contains to the objects in the room, and, in a small measure, by convection currents of air heated by contact with the radiator. With indirect radiation, the radiator is placed in a flue or duct and air is allowed to pass over it and into the room, there being no radiator in the room itself. With the indirect-direct system, the radiator is placed so that its radiated heat is utilized and it is made more effective by introducing air into the room near the base of the radiator. This air, being heated by contact with the radiator, diffuses throughout the room and aids in warming it.

Hot blast differs from the indirect in that all the heating surface is contained in one heater and that the air is forced over this heater and is discharged from it into the room by a mechanically operated fan.

47. The Hot Blast

It is this last method of heating with which this book is most concerned. Air is made the conveyor of heat and direct radiation is eliminated. This method, moreover, includes the advantage of ventilation that may be derived from the air used to convey the heat, as this air is not heated to a sufficiently high temperature to destroy its freshness and. value for ventilating purposes. The advantages of this method of heating are easily apparent, and in another section of this book the most important are brought forward for the consideration of those interested in this phase of the heating and ventilating questions.

48. Cooling

Besides providing means for heating, the ventilation system may be used for cooling as well. Modern, first-class buildings, such as hotels, restaurants, banks, offices, court-houses, legislative halls and theatres, are ventilated by the most up-to-date apparatus, and in most cases provision is or should be made for supplying cool air during the summer months. In large cities, where buildings are crowded together and where there is little chance for natural cooling, it is especially necessary to make provision for artificial cooling in the summer.

Where it has been tried, the cooling of factories and mills, where many operatives are employed, has been found to result in the higher personal efficiency of every individual and in his increased economic value.

49. By Ventilation

By simply operating the ventilating fan and forcing air into the building, a slight cooling effect is obtained as the incoming air flushes the room and drives out the vitiated and warm air. In shops, foundries, boiler rooms and engine rooms, this is the method generally employed. Kitchens, restaurants, small theatres and rooms of like character are often cooled by removing the warm air by means of exhaust fans. Propeller fans are quite generally used for cooling places where no other provision can be made. Wherever an effective ventilating system has been installed, the fans may be run in the summer for ventilation and cooling.

50. By Air Washers

In the installation of a mechanical ventilation system in which an air washing apparatus is used, the temperature of the air delivered by the fans may be materially lowered. Contact with the water spray of the air washer will cool the air within a few degrees of the temperature of the water. Of this method of cooling more is said in Section 14, Chapter I, of this book. This system of cooling is particularly applicable to hotels, banks, office buildings, theatres, court-rooms and public buildings where complete heating and ventilating apparatus is installed.

51. By Refrigeration

The third way in which buildings may be cooled by the ventilation system is by refrigeration. The air is cooled by contact with cold pipes containing cold water, brine circulated by the refrigerating apparatus, or by direct expansion refrigerating pipes, and is delivered to the room at a low temperature. Large office buildings that have refrigerating apparatus in their equipment can use this method with great economy.

A combination of refrigeration and air washer methods of cooling is sometimes resorted to when there are direct expansion or brine pipes introduced into the spray chamber of the air washer. Frost is prevented from forming upon the pipes by the water which is constantly flowing over them. The air is cooled by direct contact with the pipes containing the cooling fluid and by intimate contact with the air washer spray water, which has been chilled by the cold pipes.

Another means of cooling is secured by filling special racks with cakes of ice, arranged to allow the air to pass over them. This system has been used in offices and halls as a cooling device. Where an auditorium is to be cooled only a few times during the season, this method is perhaps more economical than installing the refrigerating apparatus for this particular purpose.

CHAPTER IV

THE STURTEVANT SYSTEM

52. Introduction of the Hot Blast System

IT will be seen that the method of hot blast heating has advantages not possessed by the others, the greatest being that of ventilation, heating and air cleansing combined in and provided for by the same apparatus. The advantages of such a combination are evident. For purposes of ventilation, the fan was originally applied some fifty years ago, but only to a limited extent, and it was not until the fan and steam heater in marketable forms were introduced by the B. F. Sturtevant Company that the so-called " Blower System " became a reality. The system, of which these two elements are the most important factors, as originally installed by this Company, has naturally been known as the " Sturtevant System." This system is at once practical, successful and economical, for air being a natural conveyor of heat, it may, when properly warmed and supplied, perform the double office of heating and ventilating. Added to this original combination is the present-day air washer, an apparatus, as heretofore pointed out, of unquestionable value in the modern ventilating system. With this final completion, the Sturtevant System takes first rank among the systems for heating and ventilating modern buildings and maintains the unique position created by itself in former years of being a complete system applicable in whole or in part to any problem of ventilation, heating, cooling or air washing.

In this country, where some means of heating is usually required during about seven months of the year, the amount of heat necessary and the economy exercised in supplying it are vital questions. As will appear in what follows, convenience and economy can be secured best by an intelligent union of the heating and ventilating systems.

53. Dual Function of the Sturtevant System

Supplying as it does both heat and ventilation, the Sturtevant System is introduced into two great classes of buildings:

First, where heating is pre-eminent and ventilation is merely incidental. To this class belong almost exclusively all manufacturing buildings, storehouses, drying rooms, exposition buildings and some offices and stores.

Second, where ventilation is of primary importance and where heating is necessarily combined with it for successful operation rather than introduced as an independent consideration. To this class belong all buildings such as hospitals, and asylums, all halls of audience, including theatres, churches and schools, offices, stores and mills, and factories not included in the first class.

Where heating alone is necessary, as in large machine shops, the air generally may be recirculated. The simplest form of apparatus is used in such cases, generally consisting of heater, fan, motor or engine and piping system. Where ventilation is desired, however, the apparatus necessarily becomes more varied. Air washers are introduced, while tempering coils must often be used in connection with the washers. A more elaborate system of temperature control is generally necessary. The air cannot be recirculated. The first cost as well as the operating expense of the system designed for ventilation is naturally the greater and the engineering problems involved are more complex.

54. Cost of Heating

When heating alone is considered as the ultimate object of the introduction of the Sturtevant System, it will be found that to maintain a temperature of 70 degrees with outdoor temperature at zero, a change of air every sixteen minutes, with a temperature of about 140 degrees entering the room, will represent a fair average in the northern portions of the country. Under these circumstances, disregarding the weight or density of the air at different temperatures, the difference between the 70 degrees and 140 degrees will represent the loss by radiation and conduction. If, with the same entering temperature, the loss is greater, the temperature of the room will be lower, and *vice versa.* There is thus lost 70/140 or one-half of all the heat by this means; or if, for ready comparison, we represent each degree as a unit, not of heat, but of merely relative measurement, there will have been lost 70 units. If, in a given time, a given volume of air is delivered to the room, its cost in total heat expenditure must be measured by the number of degrees its temperature has been raised above zero; that is, upon our basis of comparison it will be equivalent to 140 units.

In the given time all of this air must escape at the temperature of the room, which is here 70 degrees; hence, the loss by this means will also be 70 units, and it can by no means be reduced except by deliberately decreasing the volume, or by increasing the difference between the internal and the external temperature. It is evident that with a fan running at constant speed and delivering a stated volume of air, the ventilation may be reduced by returning a portion of the air from the building, and the expenditure likewise lessened. The loss by radiation and conduction, on the other hand, can be reduced by sufficient, although perhaps extravagant expenditure for double or triple sash, thicker walls, back plaster, sheathing paper and the like.

If, with the same air change, all the air should be returned from the building on the impossible assumption that there is no leakage, the temperature of the air admitted would still require to be 140 degrees and the loss by radiation and conduction would be the same, namely, 70 units; but the leakage would be reduced to zero, and the total heat expenditure would be only one-half of that in the former instance.

55. Cost of Ventilating

If, now, under the same conditions of construction as considered in the previous section, the building be fully occupied and the demands of ventilation be considered, it will be necessary to reduce the time of air change, *i. e.*, increase of the volume of air delivered. If the building be occupied as a school, with the ordinary ratio of about 250 cubic feet of room space per pupil, it will be necessary, in order to supply 30 cubic feet of air per minute per pupil (a desirable amount for a school) to furnish a volume equivalent to changing the air once in about eight minutes.

With outdoor air still at zero and an indoor temperature to be maintained at 70 degrees, it is evident that with the air supply just double that in the first instance, as would be true with the eight-minute change, its temperature need not be as high; in fact, as the real heating power of the admitted air is measured only by its temperature above 70 degrees, which was 140 − 70 or 70 degrees in the former instance, there will now be required, with double the air volume, only one-half the temperature increment, or 35 degrees.

Compared by units, it will, therefore, be necessary to provide for the loss by leakage, twice as many as before, that is 2 × 70 = 140. To these must be added those supplied for radiation and conduction which with twice the volume of air and an increment of 35 degrees, will equal 70 units, or a total of 140 + 70 = 210 units. But as the volume is double, its temperature, volume for volume as compared with the first illustration, will be 210 ÷ 2 = 105 degrees, which is evidently 70 + 35 degrees.

To summarize, there will now be required 210 units as against 140 units in the first instance, an increase of 50 per cent., and three times as many as under the assumed condition of all air returned to the apparatus, while the temperature of the admitted air stands at 140 degrees for the sixteen minutes and 105 degrees for the eight-minute change.

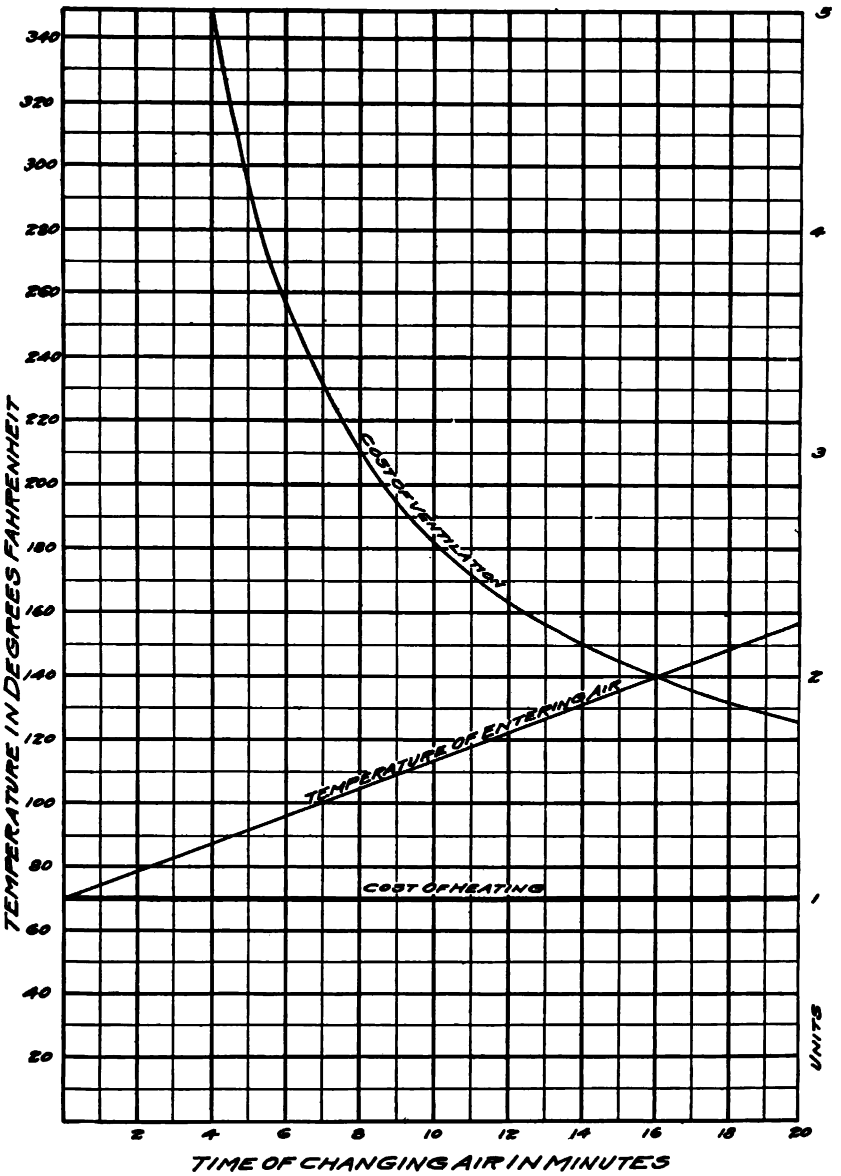


FIG. 11. RELATIVE COSTS OF HEATING AND VENTILATION WITH DIFFERENT TEMPERATURES OF ENTERING AIR.

56. The Cost of Ventilation and Heating

Inasmuch as a cold room will not be tolerated while a vitiated atmosphere will be endured, the principal reason for the comparatively large number of poorly ventilated buildings is evidently the cost of good ventilation.

The relative costs of heating and of ventilation for different rates of air change are well exemplified in Fig. 11. Here, as is proper, the cost of mere heating is shown to remain constant, but the necessary temperature of air admitted decreases while the cost of ventilation increases with the volumes admitted. It should not be assumed that where no ventilation is intended the fuel expense incurred is only that for warming. Where heating is accomplished by direct means, such as steam or hot water radiators, the effect of ventilation resulting from the infiltration of air is to add at least 5 per cent. to the mere cost of warming. Where ventilation is intentional, this may readily mount up to 100 per cent. and over. Therefore, in consideration of more effective systems of ventilation, it is only proper to consider that portion of their expense of operation which is additional to that of the existing, although inadequate, system. Viewed in this light, the cost of securing good ventilation is by no means great.

57. Relative Costs of Heating and Ventilation: Graphic Representation

The cost of heating and ventilation with the relative cost of heating alone, and temperatures of entering air are clearly presented in the diagram of Fig. 11. Of course, it is impossible to make this accurately applicable to all classes of buildings, as the lines are based upon the proportions previously given, which can only be said to represent a fair average. They do make clear, however, the approximate relations existing between the cost of heating (which is constant) and the cost of ventilation (which increases with the volume of air admitted) and serve to make evident the necessity of increased boiler capacity where the air necessary for improved ventilation is additional to that for heating, and which is measured above the line of cost for heating. The relative cost for both heating and ventilation combined is to be measured from the base line.

58. Advantages of the Sturtevant System

The advantages of the Sturtevant System although incidentally mentioned in the preceding pages, may be summarized here under two main heads.

First, adaptability and convenience.

Second, efficiency and economy.

The early consideration of the system in its entirety before the plans of the building are completed has, of course, much to do with its adaptability and the convenience with which it may be introduced.

The centralizing of the entire heating surface in a single room and within a single sheet iron jacket avoids all danger from fire, prevents the possibility of damage by leakage and removes all anxiety regarding the freezing of isolated coils. A single valve serves to control the temperature of all air admitted to the building, and the system, with its governed engine, self-oiling devices, automatic return water apparatus, damper regulator and its thermostatic control, is rendered so completely self controlling that the attendant's care is usually reduced to supplying sufficient coal to the boiler.

The system is positive in its action at all times. The air is placed where it is wanted, not merely allowed to go. The pressure created within the building is sufficient to cause all leakage to be outward, preventing cold inward drafts and avoiding the possibility of drawing air from any polluting source within the building itself.

Absolute control may be had of the quality of air supplied. It may be filtered and cleansed, heated or cooled, dried or moistened at will. By means of hot and cold mixing dampers and automatic thermostats, the temperature of air admitted to any given apartment may be instantly and radically changed in order to maintain a constant temperature.

The efficiency and economy of the system must of necessity be considered under first cost and running expense.

Circumstances so decidedly alter cases that an arrangement economical and easy of introduction in one building may prove very expensive in another. In most cases, however, the Sturtevant System, regarded simply as a method of heating, may be installed for less money than any other system of equal efficiency. Wherever the flues can be formed in the walls and the distributing ducts are of moderate extent, the system will figure less in first cost than any other capable of attaining the same results and of supplying the same amount of air. The primary cost of a fan is less than that of any other device for moving the same amount of air.

The large volume of air passing through the heater causes so great a condensation of steam that one foot of heating surface is rendered the equivalent in efficiency of three to five feet in the form of the ordinary direct radiator exposed in the room. This saving in heating surface offsets the additional cost of fan and motor or engine.

In all fairness, the operating expenses of any system must be compared upon a basis of similar conditions. The Sturtevant System, when taking its air from out-of-doors, cannot be properly compared with any system of direct radiation, for in the latter is lacking the advantage of the ventilation incidental to the operation of the former. But when the Sturtevant System rehandles and reheats the air within the building without additional outside supply, the comparison becomes more reasonable, although there will still continue to be a considerable change of air due to leakage.

CHAPTER V

HEATING AND VENTILATING APPARATUS

59. The Apparatus

WE have considered briefly and with no attention to detail the subject of heating and ventilation and the Sturtevant System of combined ventilation and heating. Before going further into the details of the system as a whole, it is well to become familiar with the apparatus by means of which satisfactory results are obtainable. This introduces the fan, the heater and the air washer, these being the most important. With a clear understanding of the design, the underlying principles and the functions of these apparatus, we can best apply the general fundamental principles of ventilation and heating already laid down. The success of the system depends as much upon the intelligent application of the apparatus that is to give the desired result as upon the theoretical considerations of ventilation and heating themselves.

We cannot hope to treat exhaustively of a subject so complicated in theme and elusive in detail as the handling, heating and washing of air, but we do desire to place before the reader a comprehensive statement of the most important principles underlying the design and operation of apparatus to accomplish these results.

60. The Fan

The importance of the fan in the subject of heating and ventilation makes it desirable to have at least a fundamental knowledge of the principles involved in the mechanical transportation of air and the design of the fan blower. The appreciation of the

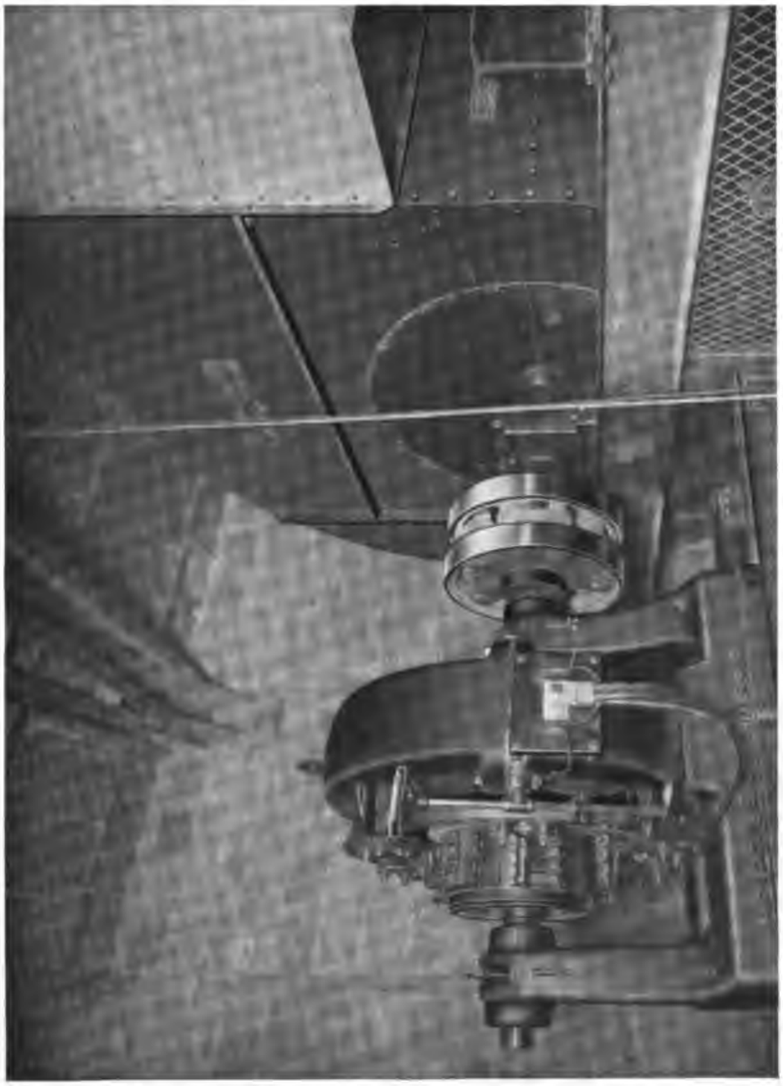


FIG. 12. STURTEVANT FAN, ELECTRICALLY DRIVEN: FOR VENTILATION.
HOTEL ASTOR, NEW YORK CITY.

possibilities of the fan blower will not only be valuable as a matter of information but will do much to guard against disappointment in a wrongly designed fan system.

61. Types of Fans

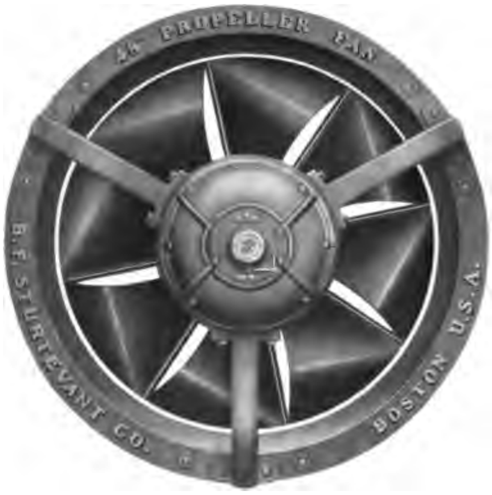


FIG. 13. STURTEVANT ELECTRIC PROPELLER FAN.

The disc or propeller fan is constructed on the order of the screw propeller, and moves the air in a direction parallel to its axis, the blades acting upon the principle of the inclined plane. The disc or propeller fan is only available for ventilating purposes when required to act against slight resistances. Where considerable resistance is encountered, the centrifugal blower or peripheral discharge fan must be used.

The blower proper consists in its simplest form of a number of blades extending radially from a shaft and presenting a practically flat surface to the air as they revolve. Air is drawn in axially at the centre and delivered from the tips of the blades in a tangential direction. This type may be designated as the centrifugal or peripheral discharge fan. The detailed construction of these fans with illustrations of their various types will be found in Chapter X.

62. Efficiency of the Fan

For purposes of ventilation where it is necessary to move large quantities of air at low pressure, there is no means so efficient as the fan, which is both economical of power and convenient to use.

Contrasted with the heated flue, the fan immediately shows its superior efficiency. The heat utilized in the operation of the flue is entirely wasted, being lost to the outside air. With the steam engine driven fan, however, the exhaust steam may be used for heating purposes and much heat saved thereby. In the following table Professor Carpenter has shown the ratio of efficiency of mechanical ventilation and that of ventilation by means of the heated flue, the air being discharged from the top of the chimney into the outside atmosphere of 60 degrees Fahrenheit temperature.

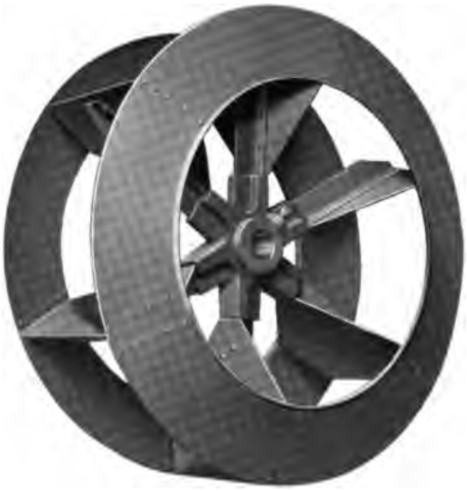


FIG. 14. CENTRIFUGAL FAN WHEEL.

63. Designation of Pressures

In speaking of pressures or resistance in connection with the flow of air in a heating and ventilating system, it is customary to speak, not of the actual pressure itself, but of the head or height of a column of water which would create an equal pressure. Thus a fan is spoken of as delivering a certain number of cubic feet of air against a maintained resistance of so many inches of water.

The relation between pressure in ounces per square inch and head in inches of water is given in Table No. 15, while Table No. 16 gives the relation between head in inches of water and pressure in ounces per square inch.

Table showing Number of Times that Fan or Blower is more Efficient than a Chimney in discharging Air from the Top. Outside Temperature 60 Degrees Fahrenheit

		EXHAUST STEAM WASTED			EXHAUST UTILIZED
Combined efficiency fan and engine		0.003	0.0066	0.0125	11.13
Condition		Poorest	Average	Best	Average
		RATIO OF EFFICIENCIES			
Height of chimney in feet	30	9.3	20.6	40.0	353
	40	7.0	15.5	30.0	262
	50	5.6	12.4	24.0	212
	60	4.7	10.3	20.0	177
	70	4.0	8.9	17.0	151
	80	3.5	7.75	15.0	133
	90	3.1	6.9	13.3	118
	100	2.8	6.2	12.0	106

Inasmuch as the fan engine exhaust is almost universally utilized, the figures in the last column are indication of the great superiority of the fan.

64. Pressure Head and Velocity Head

The flow of air through a duct or pipe is due to a difference in pressure existing at two points, and is analogous to the flow of water in a pipe by reason of a difference in height or head at two points. If there were no frictional losses in the pipe, the total head would be effective for producing flow, and the speed or velocity of that flow would be exactly that which would finally result if a body under action of gravity had fallen freely the distance measured by the head or:

$$v = \sqrt{2gh}$$

where v = velocity in feet per second
h = head in feet
g = acceleration due to gravity = 32.16.

But it is not possible that either air or water shall flow without friction through a pipe and the velocity of flow is, therefore, less than the above formula would indicate. In other words, part of the pressure exerted upon the water is employed in overcoming the resistance to flow. This is known as *pressure head* while that part utilized in the production of velocity is known as *velocity head.* Since the total difference in head is the only means of producing a movement of the water, the sum of the pressure and velocity heads must equal the total difference in head between any two sections of a pipe through which the water is flowing. With a constant total head, any increase in the length of the pipe naturally increases the pressure head and determines the velocity head accordingly. As previously stated, the phenomenon of the flow of air is analogous to that of the flow of water, water being chosen as an example merely because it is more easily observed and measured. The constant total head against which a fan delivers air is spoken of as the " maintained resistance."

The pressure and horsepower lost by friction of air in pipes 100 feet long are given in Table No. 5.

65. Pressure in Terms of Velocity

It can be easily shown that the pressure at any point exerted by a fluid at rest is equal to the head in feet measured from that point multiplied by the density of the fluid, or, if h = head, p = pressure and d = density

$$p = hd \text{ or } h = p/d$$

Now a difference in pressure created by a fan will, as previously shown, permit the flow of air at a velocity which may be theoretically calculated as follows:

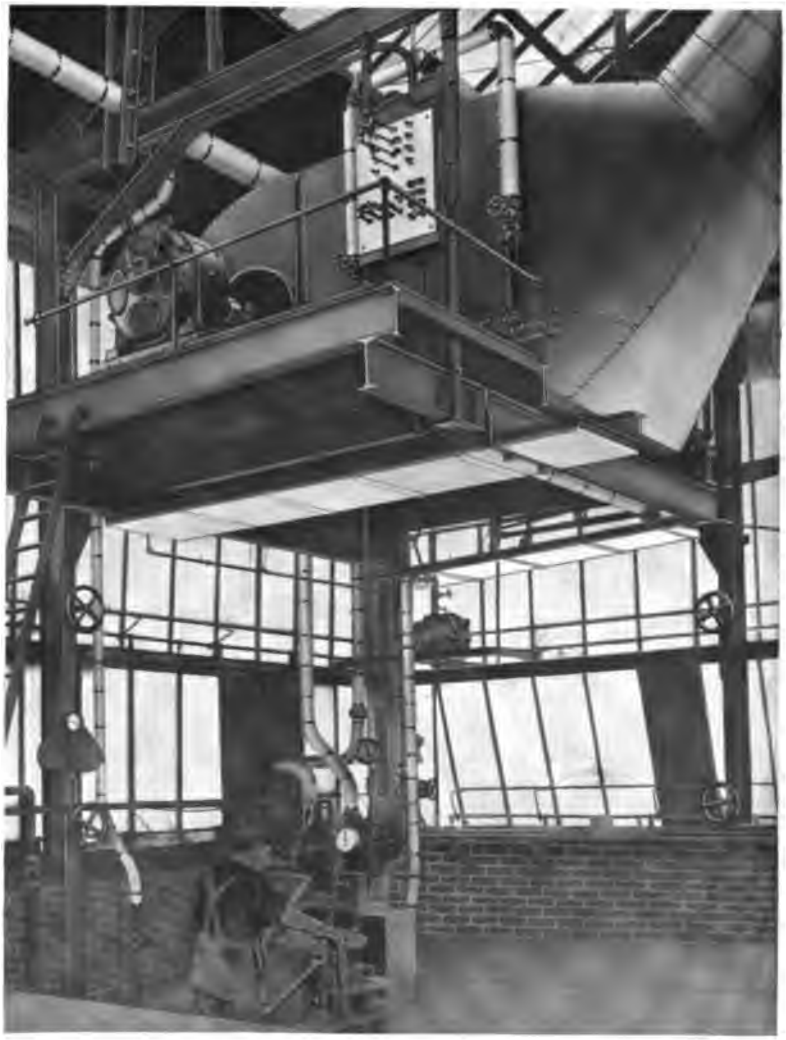


FIG. 15. STURTEVANT HEATING APPARATUS. BROOKLYN NAVY YARD.

$$v = \sqrt{2gh}$$

where v = velocity in feet per minute

g = acceleration due to gravity = 32.16

h = head in feet

and since $h = p/d$

then $v = \sqrt{2g\,p/d}$

and $p = \frac{dv^2}{2g}$

In Table No. 6 will be found the velocity created when air under a given pressure in inches of water is allowed to escape into the atmosphere. Table No. 7 gives similar information with pressures in ounces and includes volumes and horsepowers.

66. Velocity of Flow

The velocity of the fan tip, or the circumferential speed of the fan wheel which is necessary to produce a given velocity of flow through a properly shaped outlet when the outlet is within the capacity of the fan, is substantially equal to the velocity of flow. The velocity of flow, and consequently the volume of discharge, of a centrifugal fan is proportional to the revolutions of the fan.

67. Work done by the Fan

The work done by a fan in producing a velocity of flow is

$$w = pa$$

Where w = work in foot pounds

p = pressure in pounds per square foot

a = effective area in square feet over which velocity is maintained

v = velocity in feet per second.

But as previously shown

$$p = \frac{dv^2}{2g} \qquad (1)$$

and hence

$$w = \frac{dav^3}{2g} \qquad (2)$$

From equations (1) and (2) it is evident that the pressure varies with the square of the velocity and that the work done varies with the cube of the velocity or, in other words, the number of revolutions of the fan wheel. Thus doubling the speed of the fan, the pressure maintained over a given area within the capacity of the fan is quadrupled, while the work to be done by the fan is increased eightfold. The rapidly increasing power required to force air at high velocity is of vital importance in problems of air handling and concerns very intimately the economy of operation of the apparatus as can be readily realized.

68. Fan Casing

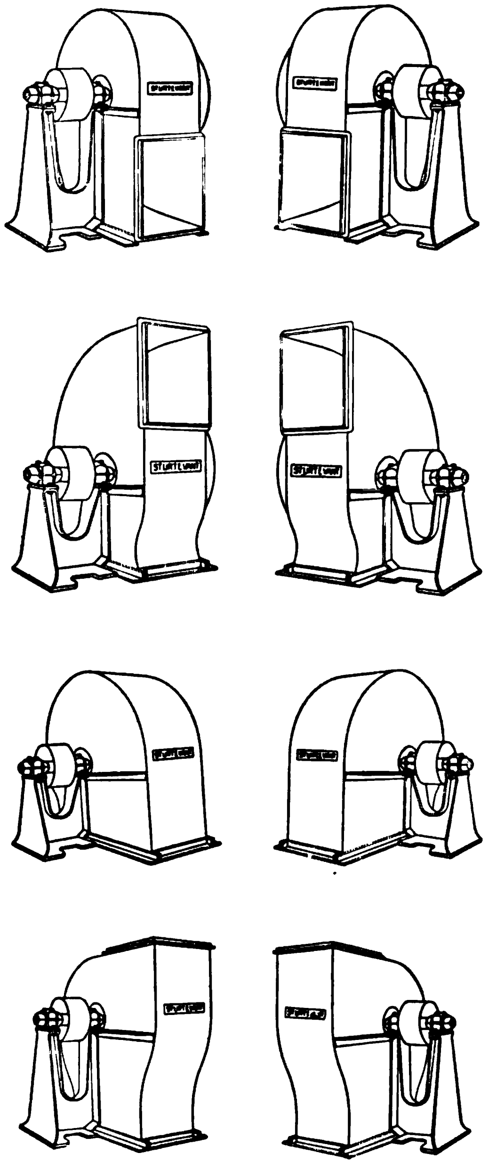
Centrifugal fans may be used without a casing to exhaust from an apartment or to establish a plenum condition within it, discharging, in that case, freely over the entire periphery of the wheel. When, however, it is desired that the entire blast from a fan wheel be directed into a duct or pipe, it becomes necessary to encase the fan wheel, so that the discharge is confined to one portion of the periphery. This casing is spiral in form, the clearance between it and the periphery of the fan wheel steadily increasing as it proceeds from the point of cut off to the point of discharge. Upon the proper design of such a casing, much depends, and experience, as well as theory, must be brought into play.

The square inches of blast for a given fan, or the capacity area, may be easily determined by the empirical formula:

$$\text{Capacity Area} = \frac{DW}{X}.$$

Where D = diameter of fan in inches
W = width of fan wheel at circumference in inches
X = a constant dependent on type of fan and casing.

The value of X has been very carefully determined by this Company for different types of fans, but these values must be applied with great discretion, acquired through experience and



Left Hand Bottom Horizontal Discharge.

Right Hand Bottom Horizontal Discharge.

Left Hand Top Horizontal Discharge.

Right Hand Top Horizontal Discharge.

Left Hand Down Blast Discharge.

Right Hand Down Blast Discharge.

Left Hand Up Blast Discharge.

Right Hand Up Blast Discharge.

Fig. 16. Hand and Discharge of Fans, Overhung Wheel Fans.

a thorough knowledge of all the conditions liable to affect the fan in operation. An approximate value of X for general practice is not far from 3, but this is used only to determine the capacity area over which a given pressure may be maintained. This is not a measure of the casing inlet, which is always larger than the square inches of blast. As a consequence, the pressure is lower, and the volume discharged is somewhat greater than would result through an outlet having the square inches of blast for its area. The maximum pressure may be realized when the sum of resistances is equivalent to the reduction of effective outlet area to that of the square inches of blast.

The volume and power required will increase with the area of the outlet, being greater with a normal outlet than with that representing the capacity area. The increase is not proportional to the area for the pressure, and consequently the velocity will be lower with a larger area. The greatest delivery of air and the largest consumption of power will occur when the fan discharges entirely around its periphery.

69. Designation of the Casing or Housing

Under certain conditions a fan casing, or housing as it is also called, encloses only a part of the fan while the lower part is completed by another form of enclosure. Thus the lower part of the fan casing may be built of brick or concrete while the upper part is constructed of steel plate. The fan is then said to have a three-quarter or seven-eighths housing as the case may be, while the term "full housing" designates a fan entirely enclosed in the standard steel plate casing. A three-quarter housing fan may be seen in Fig. 8, while a full housing fan is shown in Fig. 22.

70. Hand and Discharge of Fans

The proper designation of centrifugal fans is a matter of considerable practical importance. Distinctive terms for the various designs of fan casings have been adopted by which the relative position of the driving pulley or motor and the direction of the discharge blast may be accurately specified. Thus a fan is said to be of up blast, down blast, top horizontal or bottom horizontal discharge, as the case may be. Angular discharges are designated as top angular up blast discharge, top angular down blast discharge, bottom angular up blast or bottom angular down blast discharge. As one stands facing the outlet of a fan, a pulley, motor, engine or other form of drive appearing on the right side of the fan casing characterizes the fan as being right hand, while the drive being on the left denotes a left hand fan. Fig. 16 clearly illustrates the various discharges and hands of fans.

71. Blowers and Exhausters

Theoretically, there should be a difference in the form of the wheel designed for creating pressure and vacuum, but practically the difference between the blower and exhauster is one of adaptation, rather than construction. The blower is used to force air into a given space, while the exhauster is employed to remove air from an enclosure. For convenience of attaching pipe connections, exhausters are provided with but one inlet while blowers are provided with two inlets, one on either side. Fig. 23 shows a centrifugal blower and Fig. 22 shows a centrifugal exhauster.

72. Overhung Wheels and Pulleys

In the smallest sizes of exhausters, the bearings are both on one side of the casing and the fan wheel is overhung within the casing. In the case of a motor, engine or turbine drive, the fan wheel is then mounted upon the shaft of the driver. Where a bearing is provided on each side of the fan wheel, as is the case with fans of large diameter, the driving pulley is overhung. When driven by a direct connected motor, engine or other drive, the shafts, in this case, are generally joined by a flexible coupling.

The fact that the inlet of an exhauster is often connected to piping makes the overhung wheel better adapted for this type of fan. Both sides of a blower are usually accessible for oiling, so that the overhung pulley type is as convenient as the overhung wheel. Fig. 16 shows the overhung wheel type of fans.

73. Hot Blast Heaters

Hot blast heaters are of two general types — the original Sturtevant pipe coil type made of steel pipe screwed into cast iron bases, and the cast iron type. The original Sturtevant pipe coil heaters have been used successfully for years and are carefully designed to give the maximum condensation per square foot of heater area. Loops of pipe are screwed into a cast iron base that is divided into a supply and a drip section as shown in Fig. 122. A full description of the various types of hot blast heaters will be found in Chapter X. The steam, circulating through these loops, is condensed, giving up its heat to the air as it passes over the pipes. The rate of condensation depends upon the velocity of the air and the difference in temperature between the air and the steam. It is affected by the spacing and arrangement of the heater coils, an arrangement permitting intimate contact of the air with the pipes being the most efficient. For this reason, the coils are set " staggered," that is, every other row of pipes is set so that the pipes are directly behind the open spaces between the pipes of the intervening rows.

The pipes are arranged so that the free area through the heaters is about 40 per cent. of the total cross section area of the heater. If the free area is restricted, the resistance through the heater becomes excessive and if, on the other hand, it is too great, efficiency of heat transmission is lost. There is, therefore, a relation between the resistance of the air through the heater and the efficiency of the heating surface upon which the dimensions and arrangements of the heaters and pipes in the heaters depend.

As explained more fully in another section, hot blast heaters are made in sections that can be arranged for various areas and depths. In the combination of these sections to make a heater, the question of resistance through the heater as it is increased by adding to the depth becomes important.

The cast iron hot blast heater used in connection with some installations of Sturtevant apparatus consists of cast iron sections provided with supply and drip connections and covered with protuberances which increase the radiating surface and facilitate the intimate contact of air with the surface without increasing the bulk size of the heater.

74. Use of Steam in Sturtevant Heaters

Sturtevant hot blast heaters are intended for use with steam, either live or exhaust. Where manufacturing establishments are supplied with steam boilers, it is only necessary to run a steam line to the heater. If exhaust steam from the factory engine is available, considerable economy may be effected by using it rather than live steam. Where this is done, it may be desirable to provide for the use of live steam as well as exhaust, so that the apparatus may be used at night and when the factory engine is not in operation. A reducing valve may be used to lower the pressure to that used in the heater, although Sturtevant heaters are built for both high and low pressures. If the fan is engine driven, the exhaust steam from the engine, used in the heater, is often sufficient to heat the factory through the night. If there is no power boiler to supply steam, an ordinary steam heating boiler may be installed.

75. Value of Exhaust Steam

Most important to every manufacturer is the complete utilization of his exhaust steam, for it usually has a value as a heating medium of nearly 97 per cent. of ordinary high pressure steam. It is obviously unwise to employ live steam for heating when exhaust is at hand or even at some distance, for the expenditure for the steam pipe for such waste steam will almost always be warranted.

In many systems of direct radiation, it is more or less difficult to make use of exhaust steam, but the Sturtevant heater has been designed with this special purpose in view. Furthermore, it can be arranged with one or more special sections in which may be condensed the exhaust steam from the small engine which is usually provided for driving the fan.

Although the total heat (measured in heat units) of exhaust steam and live steam at 80 pounds is very nearly the same, the difference in actual temperature is such — exhaust steam averaging about 220 degrees while steam of 80 pounds is about 323 degrees — that there is a marked difference in the rate at which they give up their heat when circulating in steam pipes across which air is flowing. This rate of transmission, as already pointed out, is proportional to the difference in temperature between the steam within and the air outside the pipe, and, therefore, exhaust steam requires, for the condensation of a given weight of steam in a unit of time, a larger area of surface than live steam.

Furthermore, exhaust steam being less dense than live, it must require a larger pipe to convey the same weight. The proper proportioning of the areas of steam conducting pipes, according to the pressure, seldom receives sufficient attention. Table No. 11 is therefore presented to show the amount of steam of given pressure that will flow per minute through pipes of various sizes with a loss of only one pound of pressure. From this may be easily determined with sufficient accuracy the size of steam pipe required to conduct a given weight of steam of known pressure. Table No. 36 shows the usual size of steam and drip connections with Sturtevant heaters of various sizes and with steam at various pressures.

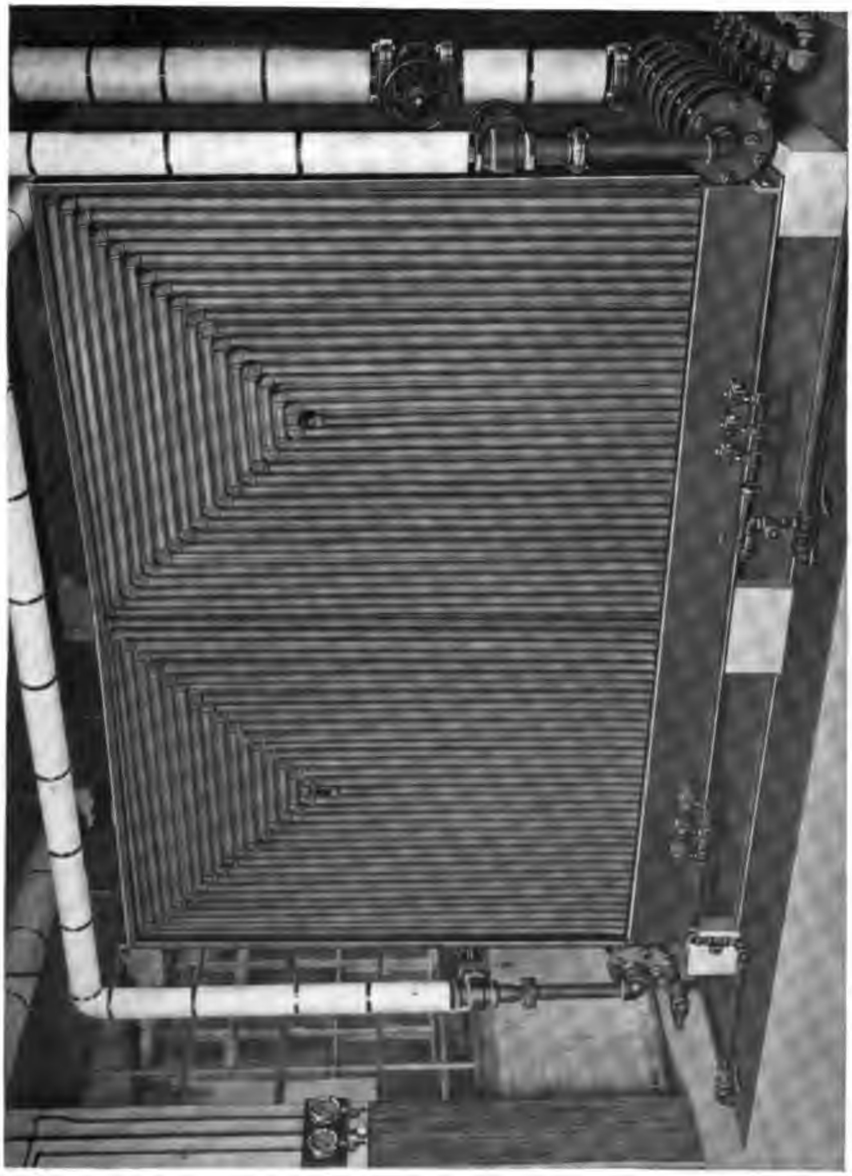


Fig. 17. Sturtevant Double Heater, used with Vacuum System. Pierce Arrow Motor Car Co., Buffalo, N. Y.

76. Vacuum Systems

There are various systems of vacuum heating that can be used with Sturtevant heaters. It is sometimes necessary, when these systems are used, to provide special drip connections, a change that is easily made upon regular heater sections. Thus the user of Sturtevant apparatus may suit his own desires as regards the steam pressure to be used upon the heater and may use any of the various vacuum systems. A Sturtevant heater for use with a vacuum system is shown in Fig. 17.

77. Hot Water

When there is waste heat from manufacturing processes that can be used to heat water, considerable saving can be made by using the hot water in the heater coils. When this is done, the mitre type of heater section (see Chapter X) is generally used as it offers less resistance to the flow of water. The temperatures possible with hot water are not as high as can be obtained with steam, and on this account more heating surface is required in a hot water than in a steam heater. The number of thermal units contained in one pound of water is found in Table No. 9, which will be found useful for calculations involving this heating medium.

78. The Effect of Moving Air on Heaters

A moving current of air has the effect of greatly increasing the rate of condensation within a steam coil. Even the slight movement due to the heated air rising from the radiator will affect the rate of condensation in a radiator placed at the bottom of a flue. The faster the air is moved, up to certain limiting velocity, the higher the rate of condensation and consequent transmission of heat from the heater to the surrounding air. For air velocities used in hot blast heating from three to five

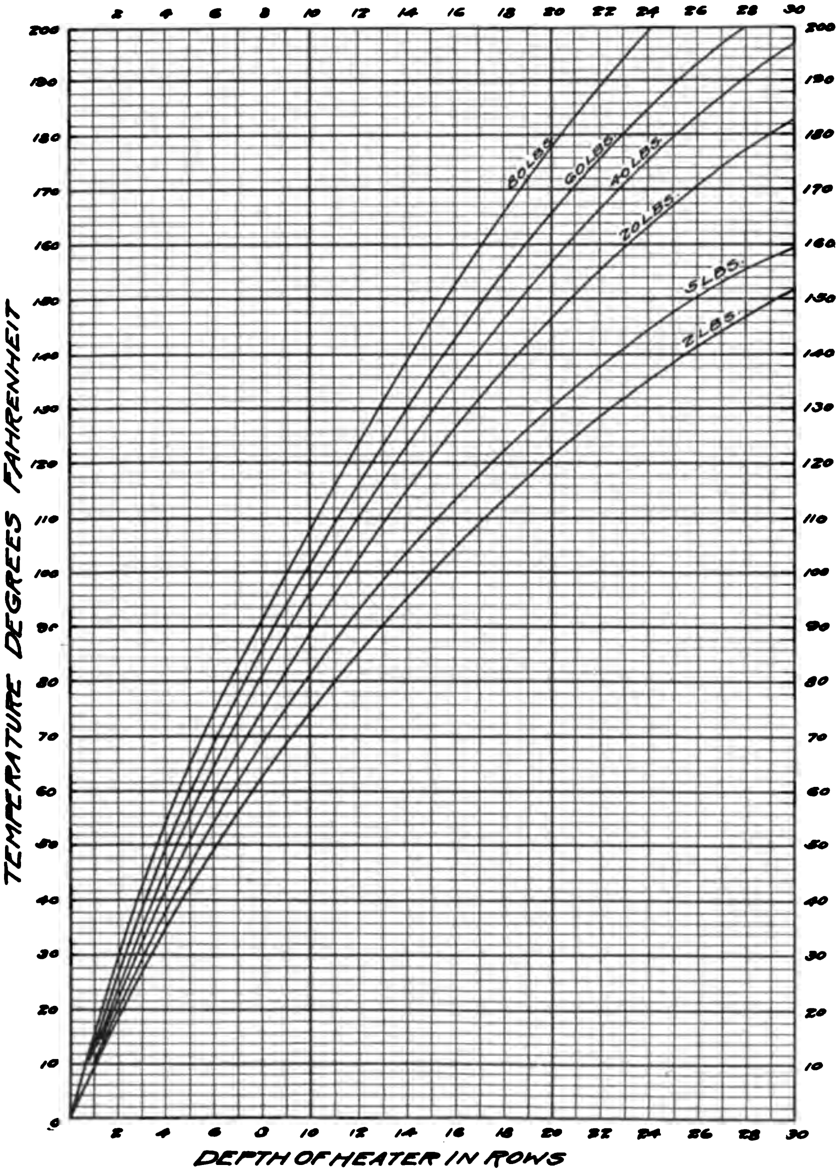


FIG. 18. ACTUAL TEMPERATURE INCREMENT AT VELOCITY OF 1200 FEET PER MINUTE.

times as much steam is condensed as is condensed in a heater over which there is no movement of air but of the same size and temperature. In other words, only from one-third to one-fifth as much radiating surface is required, under ordinary circumstances, as is necessary with direct radiation heaters, owing to the greater rate of transfer of heat to moving air from indirect heaters. Table No. 13 shows the rapid increase in the rate of transmission of heat from the heater to the surrounding air with an increase in the velocity of the air.

79. The Performance of Hot Blast Apparatus

The one inch pipes in a regular Sturtevant heater section are set on 2⅛ inch centers, providing an area for the passage of air of about 40 per cent. of the gross area of the section. 1¼ inch pipe sections are built on 2½ inch centers.

In passing through the heater, the increment due to radiation is very slight, the air being warmed by direct contact with the pipes. With a temperature difference of 150 degrees between steam and air, in the case of a direct radiator in still air, about 1.85 B. T. U. are transmitted per hour, for every degree difference in temperature between steam and the air, while with a velocity of 600 feet per minute over the heater, this is increased to 6 B. T. U. With a velocity of 1200 feet per minute, as is easily the case with hot blast apparatus, about 10 B. T. U. are transmitted, or 5 times as much as with still air. Charts of Figs. 18 and 19 show the effect of different velocities and steam pressures as determined from tests with Sturtevant heaters in connection with fans.

The rate of transmission and consequent condensation naturally depend, as already pointed out, upon the difference in temperature between the air and the steam, and are, therefore, greatest with the maximum differences; hence, the less the depth of the heater, the less the total temperature increment of the air, but the more rapid the transmission from the steam to the

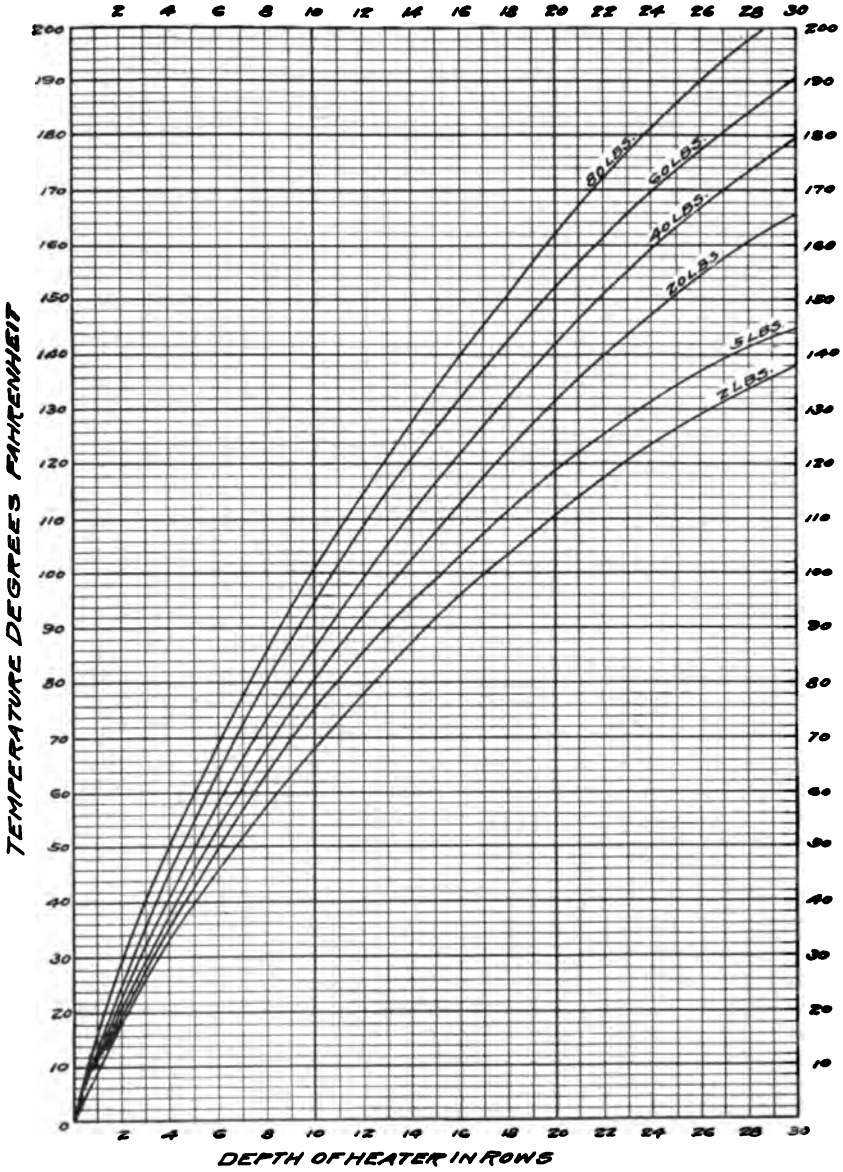


FIG. 19. ACTUAL TEMPERATURE INCREMENT AT VELOCITY OF 1800 FEET PER MINUTE.

air. With increased depth of heater, that is, the number of rows of pipe across which the air must pass, there is a corresponding decrease in the average condensation per square foot. The surface first exposed to the entering air continues to maintain the same efficiency, but the surfaces subsequently passed over are progressively exposed to smaller and smaller temperature differences, and consequently heat the air less and less. Beyond a certain limit, the low efficiency of added heater surface does not warrant its introduction. From Figs. 18 and 19, showing actual temperature increment at 1200 and at 1800 feet per minute velocity between the pipes, the performance of any Sturtevant heater may be determined for the specified conditions. The total number of rows required to heat from zero to a given temperature with a given steam pressure is found by measuring horizontally from zero to the point on the intersection of the given temperature and steam pressure lines. If the entering temperature is above zero, the number of rows will be less, and may be readily determined. Fig. 18 for 1200 feet velocity is applicable for public buildings and low velocity work, while Fig. 19 for 1800 feet applies for factory heating. The higher the velocity, and consequently the larger the volume, the less the rise in temperature, but the greater the total amount of heat transmitted as measured by condensation. This is indicated by the curves in Fig. 20, showing the effect of velocity on the relative temperature increment and condensation. The curves in Fig. 21 show the decreased efficiency resulting from additional rows of heater piping. Through these two curves it is evident that the greatest surface efficiency is secured with the highest velocity of air and the least depth of heater. It is, however, necessary to limit the velocity of the air and to make the heater of sufficient depth to give the required temperature increment to the air.

The relations of volume, weight and pressure of air and speed and power of a fan with air at different temperature are found in Table No. 4.

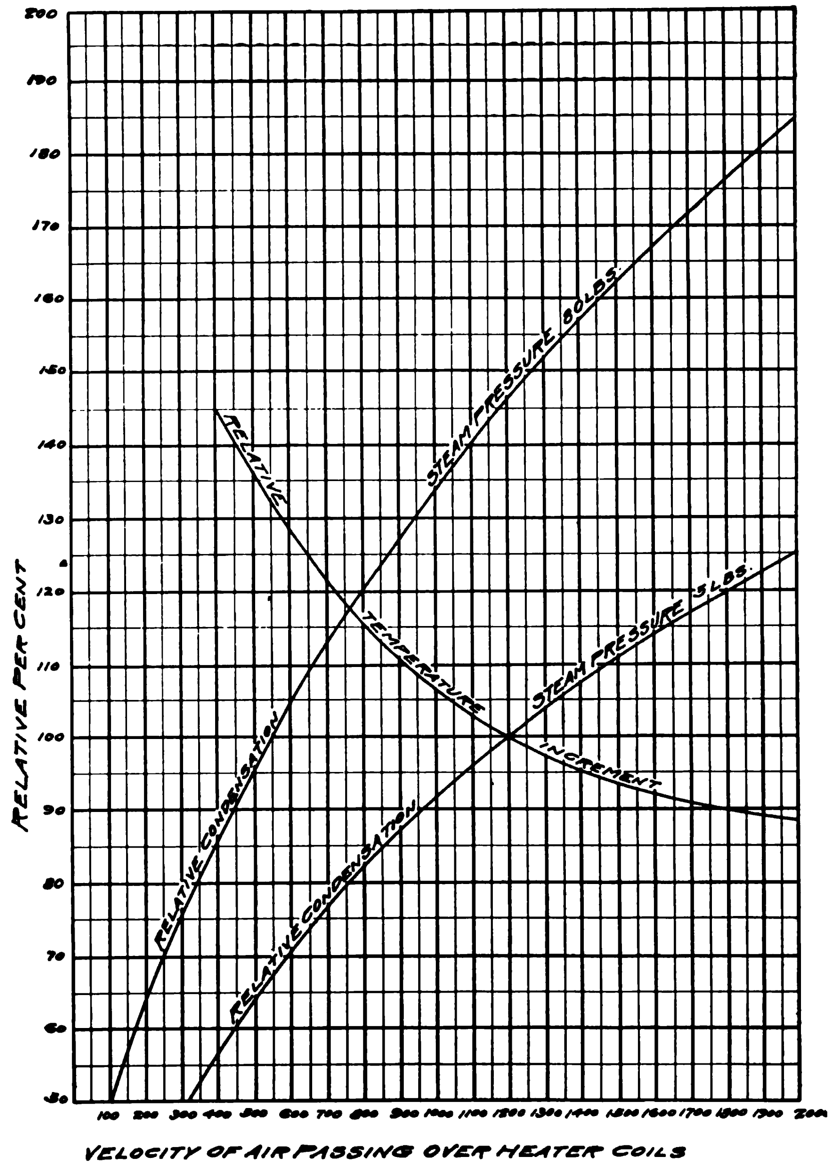


FIG. 20. EFFECT OF VELOCITY ON THE RELATIVE TEMPERATURE INCREMENT AND CONDENSATION.

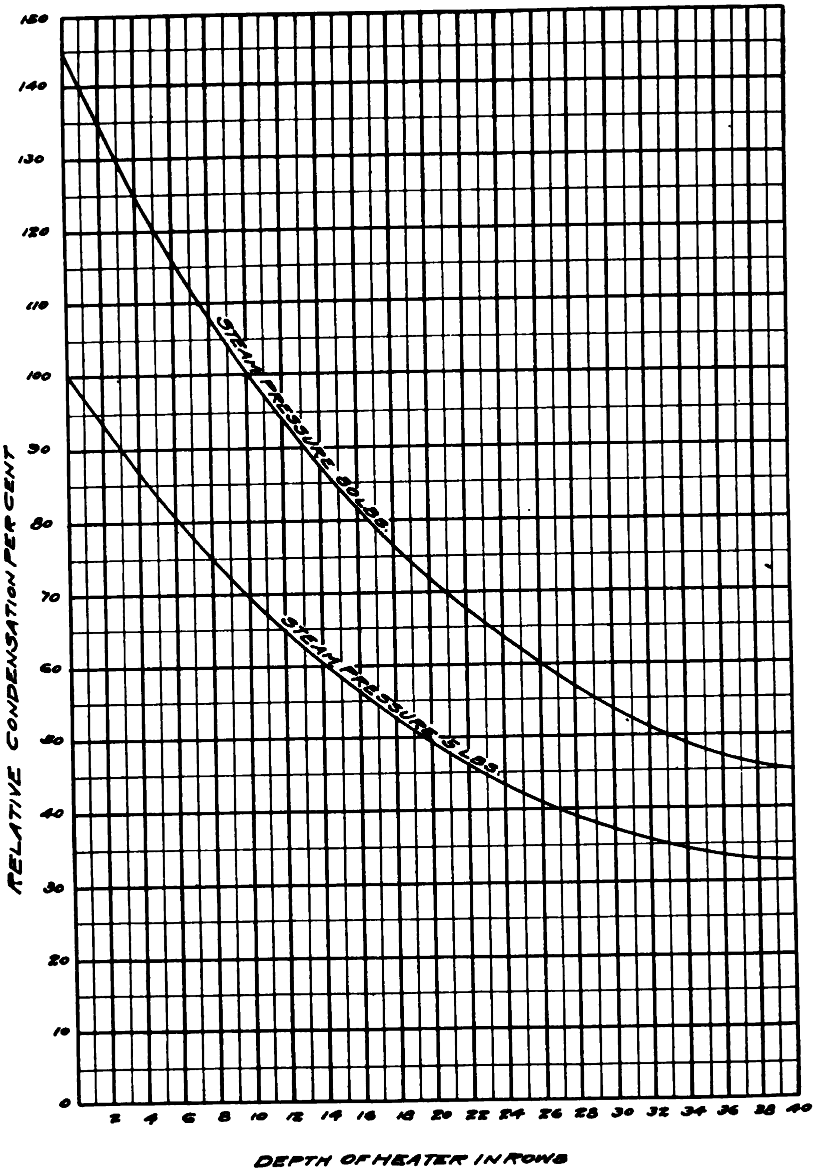


FIG. 21. RELATIVE CONDENSATION IN DIFFERENT ROWS OF STURTEVANT HEATER FOR A VELOCITY OF 1200 FEET PER MINUTE.

80. Heater Casings

It is necessary to provide a casing of sheet iron, for hot blast heaters to confine the air in a definite channel through the heater. These casings, or jackets, as they are called, are built generally of steel plate and angle irons and cover the top, sides, and sometimes the bottom of the heater. The jacket is also, as a rule, connected to either the inlet or outlet of the fan, as explained later, although, in certain arrangements, this connection is made in other ways. If the heater is connected to the inlet of the fan, the combination is known as a " draw-through " apparatus; if it is connected to the outlet, it is called a " blow-through " apparatus. The selection of the style of apparatus is dependent upon various conditions, each style having advantages which recommend its use in different situations. The available space or the arrangement necessitated by the shape or size of the space available often affect the style of combination chosen.

81. Draw-through Apparatus

The general arrangement of " draw-through " apparatus is to place the heater in a jacket connected to the inlet of the fan. In this case, the exhauster type of fan, having an inlet on one side only, is used. A double inlet is sometimes used, with suitable dampers, so that air may be drawn over the heater, or, when it is unnecessary to use the heater, directly from the source of supply without passing over the heater. When for the heater jacket is substituted a heater room, as is sometimes the case, the entrance of the heater room being blocked with heaters, a double inlet fan or blower may be used.

Draw-through apparatus is most generally used where the primary object of the system is heating, such as in factories and roundhouses. The apparatus is very compact and takes up comparatively little room. It may be easily mounted aloft on a platform or on members of the roof trusses. A typical draw-through apparatus may be seen in Fig. 22.

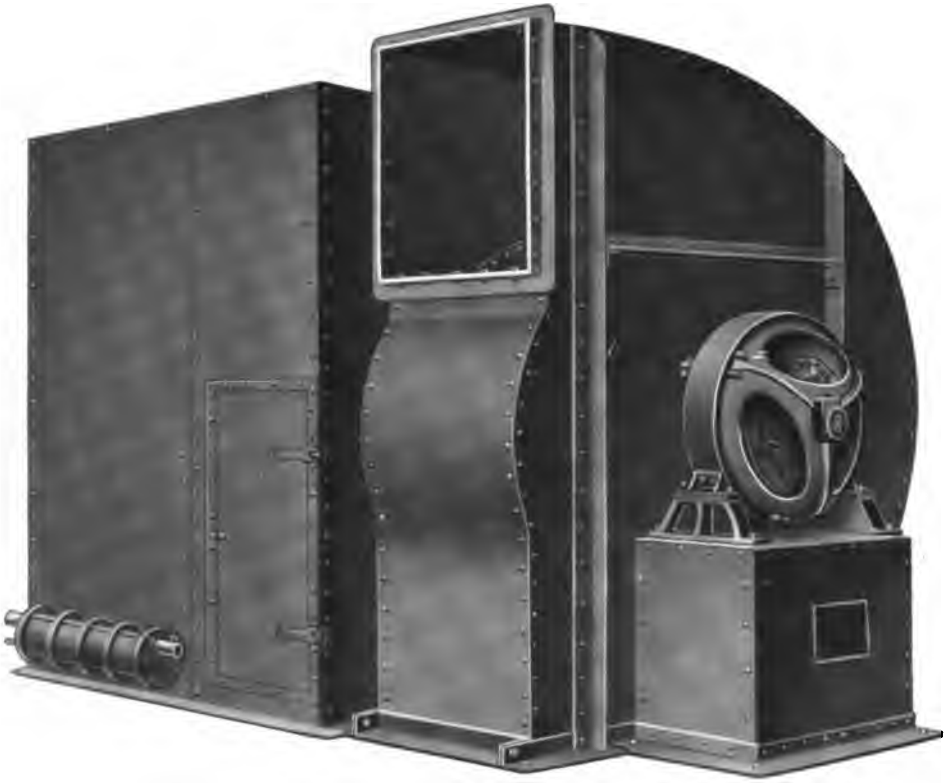


FIG. 22. STURTEVANT HEATER, FAN AND MOTOR — DRAW-THROUGH APPARATUS.

82. Blow-through Apparatus

The general arrangement of the blow-through apparatus is to place the heater so that the jacket is connected to the outlet of the fan, the air being blown through the heater. For this purpose, either a single or double inlet fan may be used. The outlet from the heater jacket may be placed in almost any position at the end of the heater, so as to discharge either directly outward at the end or upward, downward, to the right or to the left. The discharge from the fan is always made such as to cause the most thorough circulation of the air passing through the heater; that is, with the discharge at the top of the heater the fan would probably have a bottom horizontal discharge. A blow-through apparatus is shown in Fig. 23.

By arranging a by-pass either above or below the heater coils, the fan will deliver air at two temperatures, according as it goes through the heater or through the by-pass. By means of suitable dampers, the relative proportions by volume of the air at the two temperatures may be regulated and the temperature of the final mixture controlled. The dampers may be operated by hand or automatically by pneumatic diaphragms, thermostatically controlled.

83. The Steam Trap

The necessity of providing a drip and apparatus for draining the condensed steam from the heater is evident. The apparatus used for this is the steam trap explained and described in Chapter X. The function of such a trap is to permit the passage of water unaccompanied by steam from the heater.

The requirements of a trap for this type of service are that it shall be reliable under conditions presupposing little or no attention.

The size of trap necessary is dependent upon the amount of water to be handled and hence upon the size of the heater and the rate of condensation of steam within the heater. Table No.

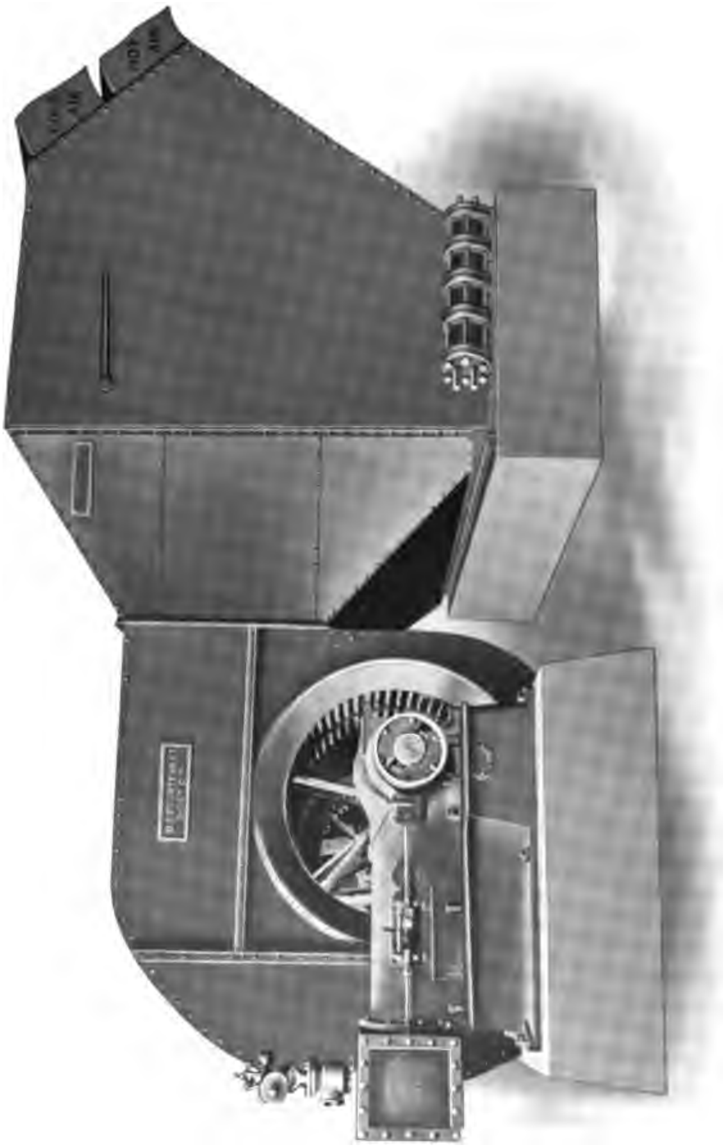


FIG. 23. STURTEVANT BLOW-THROUGH HEATING APPARATUS.

40 gives this information. The steam trap is connected to the drip of the heater and discharges the water of condensation periodically into a drain or sewer.

Where it is desired to return the water of condensation to the boiler for reasons of economy, there is used a return water apparatus, shown and described in Chapter X.

84. Types of Air Washers

There are two general types of air washers used in connection with ventilating apparatus, the dry and the wet. Both types have been used with varying success.

The dry air washer, or filter, usually consists of screens of cloth set so that the air entering the building must pass through them on the way to the fan. Such screens have many disadvantages. They soon become dirty and, unless renewed or cleaned, they offer considerable extra resistance to the heating or ventilating system. They are liable to become torn, in which case they are practically useless. At best, they remove only the largest particles of dust, and rather than destroying or removing disease germs, they may, on the other hand, become dangerous breeding places for germs.

The wet air washer has been made in several forms and represents an effort to eliminate the disadvantages of the dry washer. Cloth screens, similar to those used for dry air filters but with a stream of water running over them to assist in removing dust from the air, have been used. These are liable to clog, are dirty and unsanitary. The cloth must be frequently renewed, as it rots and tears, becoming useless under such conditions.

In an effort to clean these screens automatically, attempts have been made to utilize a broad belt of fabric running slowly over two rollers and passing through water so as to be continuously washed. The difficulty experienced with this type of washer lies in keeping the belt on the rollers. Also the cloth screen has proved unsanitary.

The coke air washer has also been used. This consists of metal screens which hold a quantity of coke, forming a screen of coke through which the air must pass. A stream of water wets the coke continuously, facilitating the separation of dust from the air. The porous nature of the coke permits it to hold considerable water while it is also pervious to the air. Coke washers, however, become befouled with dirt which cannot be removed except when the coke is renewed. Like the cloth screens they also are unsanitary.

85. The Modern Air Washer

The air washer that is in general use today has done away with such unsanitary devices as cloth screens and coke filter chambers, and instead uses water entirely to clean the air. This type of air washer consists of three distinct parts; the spray chamber, the eliminator plates and the tank for catching the spray. Besides these, there are necessary a recirculating pump for supplying the water and a screen or filter for removing the dirt from the water used in the spray chamber, as, for economy, the water is generally used over and over again in this type of air washer, replacing with fresh water when desired.

86. The Spray Chamber

The spray chamber is the most important part of any air washer of this type because the air washer ceases to perform its duty if there is no spray. It is to this part of the washer that the most careful attention should be given, and upon the proper type of spray and design of spray chamber, principally depends the success of the air washer. In endeavoring to secure the best results in air washers, three types of spray have been developed, and are known as the " mist type," the " sheet " or " film of water type " and the "spray" or " rain type." For the successful operation of these various forms of spray, it is necessary that

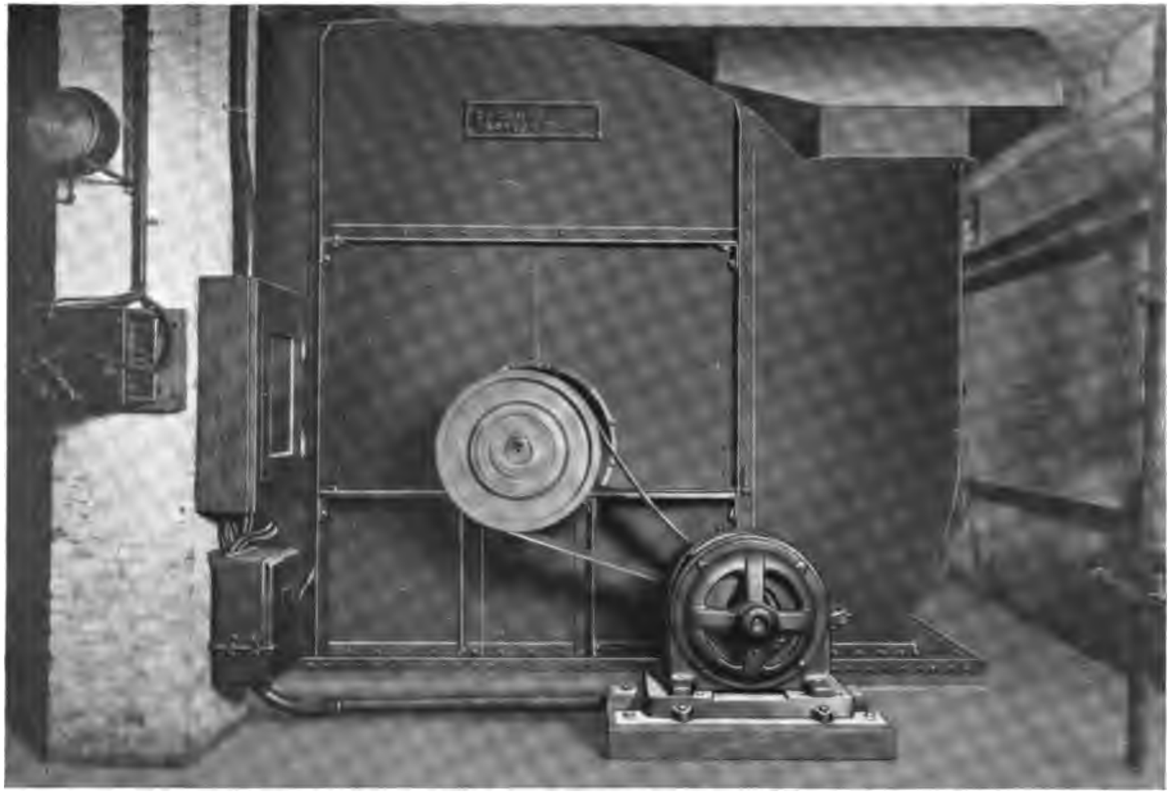


Fig. 24. Sturtevant Ventilating Apparatus. Stuyvesant High School, New York City.

the water supplied to the air washer be under a pressure of from 5 to 25 pounds.

87. The Mist Type

The spray which characterizes the mist type of washer is created by atomizing the water with a pressure of about 25 pounds per square inch by forcing it through small openings and giving it a centrifugal or whirling motion. A great many nozzles are necessary in an air washer using this type of spray and the whole spray chamber is filled with a fine mist which generally completely saturates the air with moisture.

This form of spray presents advantages and disadvantages. If the apparatus is used for air washing only, complete saturation of the air is not desired. Moreover, as much less water is used in this type than in the spray or rain type described later, there is a possibility of incomplete washing, and if the eliminators used with this type of washer are not efficient, a considerable amount of air must pass to the spray chamber unwashed, especially if the air is passed at high velocities and if the transverse dimension of the spray chamber is comparatively short. Inasmuch as the openings in the spray nozzles are generally very small (a few thirty-seconds of an inch in diameter) they clog with particles of fibre, dirt and other foreign matter. The strainer used to keep these particles from the spray nozzles must be of a very fine mesh so that, after several hours' use, these strainers become clogged and the resistance against which the pump must operate increases. This means there is a smaller delivery of water or a larger consumption of power. Where air washers are used as humidifiers, however, this mist type ensures an intimate contact between the air and the water which is a very desirable feature.

88. The Sheet of Water Type

The most common type of spray used in air washers is the sheet of water type. In order to obtain this sheet of water, a small disc is placed near the end of the nozzle so that the stream of water, issuing from the nozzle, is spread out in a film or sheet. To create such a spray or sheet of water, a pressure of from 7 to 12 pounds per square inch is necessary. These nozzles are equidistantly placed over the entire cross-sectional area of the chamber so that, when in operation, an unbroken sheet or film of water fills the spray chamber. In most air washers there are two sets of nozzles forming two sheets of water. One of the principal disadvantages of this type of spray is its liability to clog, as the disc must necessarily be placed close to the nozzle. Particles of dirt, fibre and other foreign matter lodging between the nozzles and the disc break up the sheet and leave large openings through which the air can pass unwashed. To overcome this fault, a means of removing the deposits from the nozzles while the washer is in operation is necessary so that the sediment may be washed away. This device is generally operated automatically. Moreover, owing to the form of the spray issuing from the nozzles, it is probable that in the immediate vicinity of the nozzle the film of water cannot be broken up by the air so that the air is forced to pass through the weak places in the spray which are at the edges of the films, thus lowering the efficiency of the washing process. This type of spray does not saturate the air as much as the mist type, so that nozzles, forming a mist spray, or auxiliary steam nozzles must be introduced if the washer is to be used as a humidifier.

89. The Rain Type

Most successful for air washing purposes is the rain type of washer. In some washers of this type the spray is formed by water issuing from a perforated pipe in streams which strike tangentially against a sheet of metal, causing the streams to break and spread out in such a way that the water leaves the edges of the metal sheet in the form of rain. These openings are so arranged and placed that the drops of water do not follow along parallel lines, but cross one another within the spray chamber. Another method of producing this rain or spray is by means of properly designed nozzles. With this type of washer, a pressure of from 5 to 9 pounds is necessary.

One of the principal advantages of this rain spray is that the nozzles have comparatively large openings, overcoming the tendency to clog and eliminating the necessity of a flushing device. Moreover, the spray does not saturate the air as much as the mist type, which is of advantage when used as an air washer.

90. Eliminators

Eliminators are, second only to the spray chamber, the most important part of the air washer. The function of these eliminators is to remove the entrained water carried over by the air from the spray chamber before the air leaves the air washer. The eliminators are so designed that the air must change its direction several times and pass over the sharp edges of the metal sheets. The entrained moisture is deposited upon the surface against which the air impinges. The eliminators are placed either vertically or horizontally. Some are corrugated and placed 1 to 1½ inches apart; others are V shaped and placed several rows deep and " staggered " so that the air cannot pass through them without changing its direction several times. Horizontal eliminators are generally of the V shaped type with projecting edges which " wipe " the air. The superior form is one that is perforated and lipped so that the air passing through the eliminators comes in contact with the water dripping from the edges and lips, increasing the efficiency greatly. The lips on the rear parts " wipe " the moisture from the air.

Some horizontal eliminators are deep troughs, slightly inclined so that the water will flow off, down the side of the casing and into the sump, while others are shallow troughs from which the water is allowed to overflow and thus come in contact with the air in the lower part of the washer.

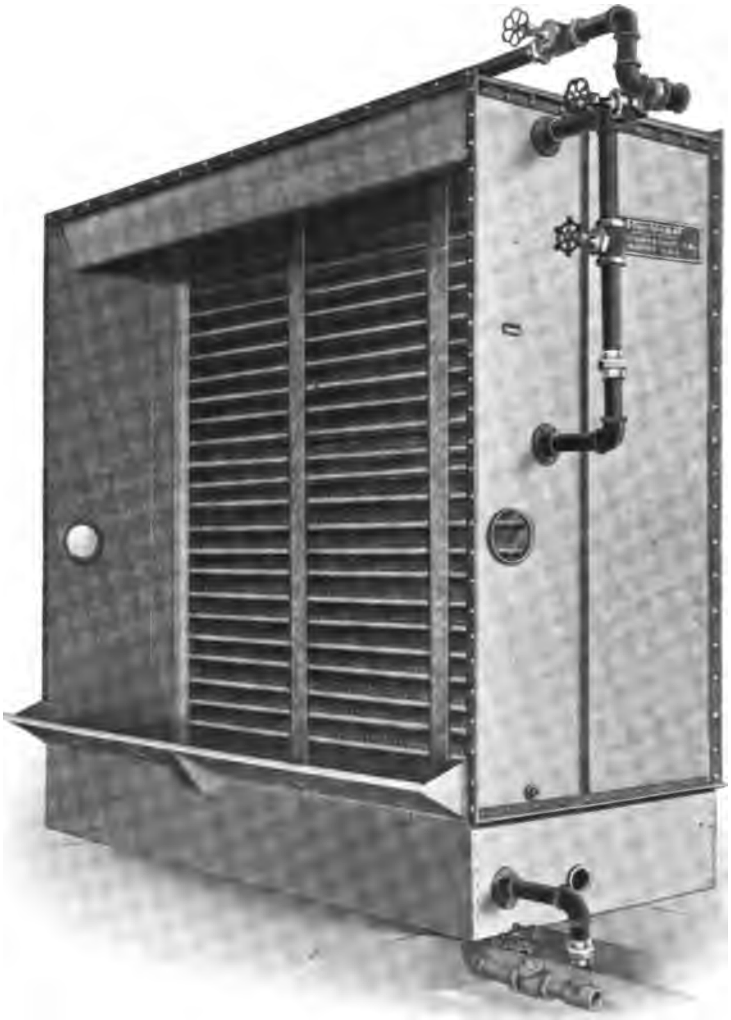


FIG. 25. STURTEVANT AIR WASHER.

91. Sump

The sump of the air washer may be constructed either of sheet metal, when it forms part of the air washer, or of concrete. The sump must be provided with a strainer and an overflow, and the height of the water within it is maintained at a constant level by an automatic valve. The strainer is generally placed in the sump and prevents sediment and other foreign matter from entering the pump and spray nozzles. In the mist type of air washer, a strainer is also placed in the discharge line of the pump.

92. The Recirculating Pump

The recirculating pump is always of the centrifugal, turbine or rotary type and is generally driven by a direct connected electric motor, steam engine or turbine, although in many cases belted pumps are used.

93. The Heater or Tempering Coil

The casing or housing of the air washer is usually connected to the casing of the heater coil. This heater is placed upon the front of the entering side of the washer so as to warm the air before it comes in contact with the water, and is necessary in order to prevent the water from freezing. If the spray water is heated, the tempering coil need not be used.

94. The Sturtevant Air Washer

The Sturtevant air washer is of the rain or spray type. The washing water is broken into a fine rain or spray by the special nozzles as described in Chapter X. Through this spray, which entirely fills the interior of the spray chamber, the air must pass before entering the fan to be blown into the building. The action of the spray has the beneficial effect of a refreshing rain storm, cleaning from the air every particle of dust and soluble impurity. The nozzles are so designed that large openings may be used, avoiding the serious fault of clogging, as found with many air washer nozzles and making flushing devices unnecessary.

The eliminators of the Sturtevant air washer are very efficient, due to their construction. They are placed horizontally across the end of the washer and are slanted louvre-like so that in passing through them, the air is brought into contact with the sharp edges of the eliminators. The eliminators are made even more effective by being punched in such a manner that lips are formed and bent outward from the surface of the eliminator. This creates a great number of sharp edges against which the air strikes while the water, dripping from these lips, increases the cleaning efficiency.

The sump entirely encloses the lower part of the spray chamber and the eliminators. The sump is watertight and is connected to the sewer for drainage. A centrifugal pump draws the water from the sump through a strainer and recirculates it through the spray nozzles so that it may be used over and over again. A description of the air washer with illustrations of its various parts is found in Chapter X.

The Sturtevant System, with its fan, heater and air washer, and taking as it does all the air admitted to the building through a single opening, completely controls the quality and the condition of the air. Where the only entrance for the air is through the doors and windows of the building, there is no way of washing, moistening or warming the air. This is one of the great defects in buildings not ventilated by the Sturtevant System. With this system, the windows may be tightly closed, excluding drafts and dust, while plenty of fresh cleaned and warmed air is provided.

By the addition of the Sturtevant air washer, the Sturtevant System, so universally adopted by architects and engineers, meets all laws of ventilation, gives ample heat in winter and can be used effectively for cooling in the hot weather.

CHAPTER VI

HEATING AND VENTILATING CALCULATIONS

95. The Solution of the Problem

In the following chapter, we have endeavored to bring to the attention of the reader, the fundamental problems of heating and ventilating in general in order to guide him in making calculations and designing systems. Success in the solution of these problems depends not alone upon a clear understanding of the fundamental principles involved, as given in this book, but upon experience as well. We can only hope to give suggestions to the reader for designing systems and making calculations for apparatus in general. His personal judgment must guide him in the intelligent use of the information given. It is, of course, impossible that a book of this kind should cover in detail every problem of heating and ventilation, much as we may desire to make it. It is, therefore, not out of place to sound a note of warning here, lest inexperienced persons commit the error of making an unintelligent application of the information contained herein.

96. Basis for Heating Calculations

The thermal value, or heating power, of water and of steam has been found by elaborate experiments, and the results are embodied in complete and convenient tables. By a proper understanding and use of such tables, in connection with tables of the properties of air, ready calculations may be made in all matters relating to steam heating. Table No. 8, The Properties of Saturated Steam, and No. 9, of the Number of Thermal Units

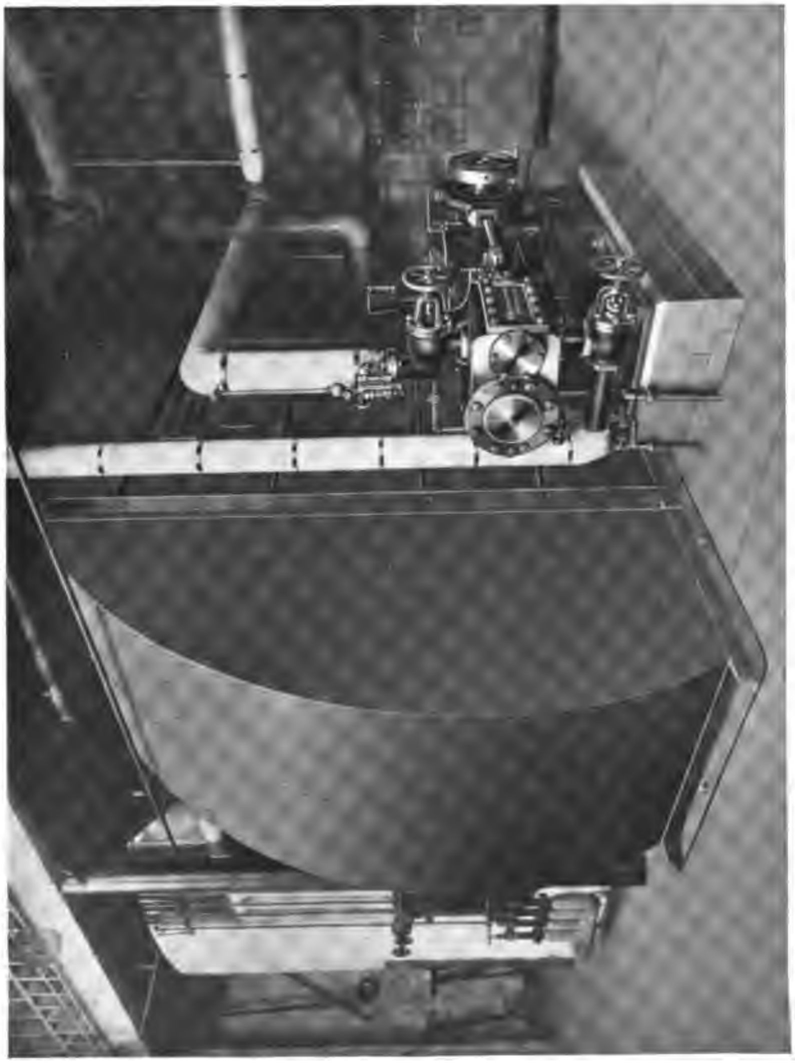


Fig. 26. Sturtevant Fan and Engine. West High School, Minneapolis, Minn.

Contained in 1 Pound of Water, embody the principal data. Table No. 1 of the properties of Air, Vapor, Saturated Mixtures of Air and Vapor, has already been presented. Figures between those given in the tables may be obtained with sufficient accuracy by interpolation.

It is customary to base calculations of heating capacity upon the number of pounds, or cubic feet, of air that can be heated by the condensation of one pound of steam. The specific heat of air at constant pressure is .2379, compared with water as a standard, or, in other words, the heat absorbing power of air is about one-fourth that of water and the amount of heat required to heat 1 pound of water through 1 degree Fahrenheit will heat 4.2034 pounds of air, through the same temperature increment. The total heat and the sensible temperature of steam increases with the pressure, as shown by Table No. 8. Upon condensation steam gives up its latent heat and is changed into water having the same temperature as the steam from which it was condensed. Hence, the heating power of a pound of steam of a given pressure is expressed by the heat thus given out, *i. e.*, by the total number of heat units in the original steam less the number in the final water of condensation.

97. Sources of Heat Loss

The reduction of temperature within buildings is the result of the combined loss of heat by conduction through and radiation from windows, doors, floors and ceilings and by direct leakage or escape of air at the temperature of the room.

The loss by conduction and radiation varies directly with the difference between the internal and the external temperatures and is proportional thereto. The material, thickness and the method of construction of the walls have an important bearing upon the rapidity of heat loss. Under general conditions, wooden buildings dissipate heat most rapidly, stone next, while brick buildings best retain the heat. Obviously, the relative window surface, in proportion to the cubic contents of the building, the climate, the location, whether high or low, or affected by winds or severe exposure and the method of heating all have an influence. With so many modifying conditions, it is evident that no unalterable rule can be given for heating all classes of buildings, satisfactory results being obtained only by calculation for each individual problem.

From the heat transmitting power of various forms of construction, as given in Section 98, Chapter VI, the loss of heat may be determined with reasonable accuracy. The conductivity of the surfaces is here expressed by the number of heat units transmitted per hour by a square foot of surface for each degree difference between the temperatures of its two sides.

Wherever the blower system is used, the cost of heat supply to make good the loss by conduction through and radiation from the walls is measured by the difference between the average temperature within the room and that of the air as it is discharged into the room, all losses in transit from the apartment being disregarded.

The loss by leakage and escape of air is measured directly by the difference between the indoor and outdoor temperatures, this representing the heat added to the air and which serves no useful purpose in heating. This loss by leakage or escape of air is occasioned by the diffusion of air through the walls and ceiling of the building and by direct leakage through cracks and imperfections in the building construction, such as loosely fitted doors and windows. Thus it is evident that with a constant volume of air, the expenditure for heating will be indicated by the loss by the first means and that for ventilation by the loss of warm air escaping by the second means.

98. Heat Transmission Coefficients

The subject of heat transmission through walls has been given careful attention by many investigators, who, as a rule, have based their assumptions and conclusions upon the work of the French scientist, Péclet. These investigators have compiled several series of coefficients to be employed in determining the relative rates of heat transmission for various substances used in building construction. This Company has used for years, and with great success, a series of coefficients given in the accompanying table. These coefficients were compiled by Alfred R. Wolff, M.E.,* to suit the climatic conditions and the practice of this country. The values given in this table represent the heat transmission in units per hour, per square foot of surface, per degree difference in temperature.

THE COEFFICIENT BEING FOR EACH SQUARE FOOT OF BRICK WALL

Thickness of brick wall in inches	4	8	12	16	20	24	28	32	36	40
Coefficient	.658	.458	.315	.258	.228	.194	.165	.143	.129	.114

1 sq. ft. wooden beam construction as planked over, or ceiled	flooring	.083
	ceiling	.104
1 sq. ft. fireproof construction, floored over	flooring	.122
	ceiling	.145
1 sq. ft. single window		1.215
1 sq. ft. single skylight		1.03
1 sq. ft. double window		.572
1 sq. ft. double skylight		.621
1 sq. ft. vault light		1.43
1 sq. ft. door (65% wood, 35% glass)		.572
1 sq. ft. door (plain)		.414

It is further prescribed that these coefficients shall be increased respectively as follows:

10 per cent. where the exposure is a northerly one, and winds are to be counted on as important factors.

10 per cent. when the building is heated during the daytime only, and the location of the building is not an exposed one.

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* "The Heating of Large Buildings," Alfred R. Wolff, M.E., New York.

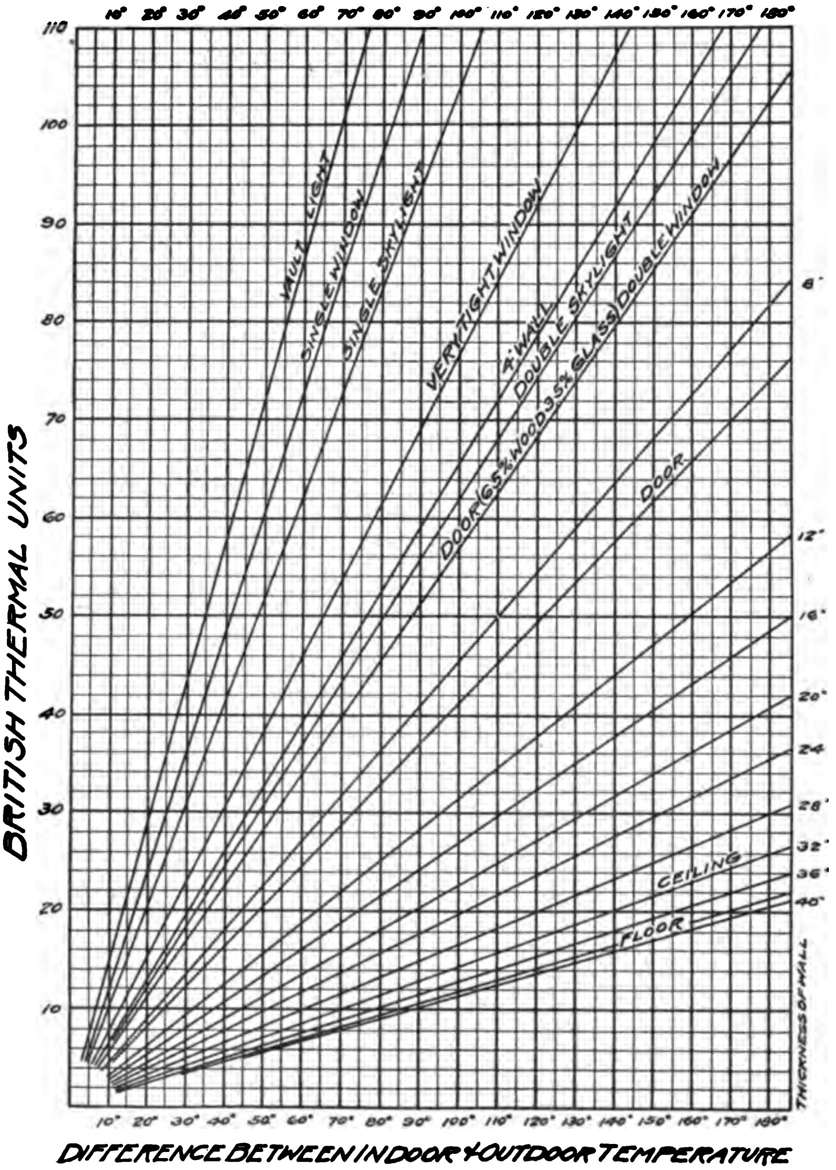

FIG. 27. HEAT TRANSMITTED IN B. T. U. PER HOUR, PER SQUARE FOOT OF SURFACE.

30 per cent. when the building is heated during the daytime only, and the location of the building is exposed.

50 per cent. when the building is heated during the winter months intermittingly, with long intervals (say days or weeks) of non-heating.

From the above, Mr. Wolff has also prepared a diagram, in form similar to that given here (Fig. 27) which serves to present the data graphically in the most comprehensive manner for practical application. By the use of this diagram it is possible to determine the total loss of heat by transmission from a given room, and thereby to ascertain the amount of heat, as measured in heat units, that must be supplied continuously to the room to make good this loss and maintain the temperature. This does not cover the additional heat necessary on account of change of air for the purposes of ventilation.

99. Loss of Heat due to Diffusion of Air through the Walls

There is a variable amount of heat lost through the gradual diffusion of air through the walls of a building, the actual amount depending largely upon the nature of the construction of the walls and the exposure. This is entirely apart from leakage due to poorly fitting windows and doors, as it takes place through the walls themselves. To overcome and reduce this loss as much as possible, there are various methods of insulation that may be employed in building the outside walls. Painting and papering inside walls reduce their porosity slightly.

100. Effect of Wind

The effect of wind upon the heating of high buildings has been investigated recently in connection with the use of weather-stripped windows for preventing air leakage. These experiments have brought out evidence to show that leakage in the ordinary building, both outward and inward, is greater than is generally imagined.

Wind blowing against a building will create a pressure on the windward side while a partial vacuum will be established on the lee side. Thus air will be forced into the building on the windward side and drawn out from the lee side. If there is any interior connection between the rooms on the two sides of the building, there will be a general movement of air from one side to another, accompanied by overheating on the lee side and cooling on the windward side. The magnitude of this effect depends upon the position of the building, the tightness of the windows and the porosity of the walls.

Wind also increases the heat loss through roofs and vent flues. When there is not wind producing a pressure on one side and a partial vacuum on the other, leakage takes place through porous walls and cracks in windows and doors because of the difference in density between outside and inside air, warm air leaving by the upper sash and cold air entering by the lower.

Leakage of air through cracks and porous walls often upsets heating calculations, as buildings in exposed places are sometimes not properly provided with sufficient heating surface to offset these losses due to high winds.

101. The Effect of Tall Buildings

The type of office building which the high cost and lack of land in congested districts have made necessary is the so-called skyscraper, tall, constructed chiefly of steel with stone, brick or terra cotta walls and abundantly supplied with windows which often form the entire wall of a room. Such buildings present problems that must be well understood or disappointment in the proper working of the heating system is certain.

Varying directly with the height of the building, the wind velocity becomes a matter of considerable importance and must be considered carefully, as the cooling effect of wind at high velocities is large. Moreover, the height to which some of the buildings are carried as compared with other buildings in the

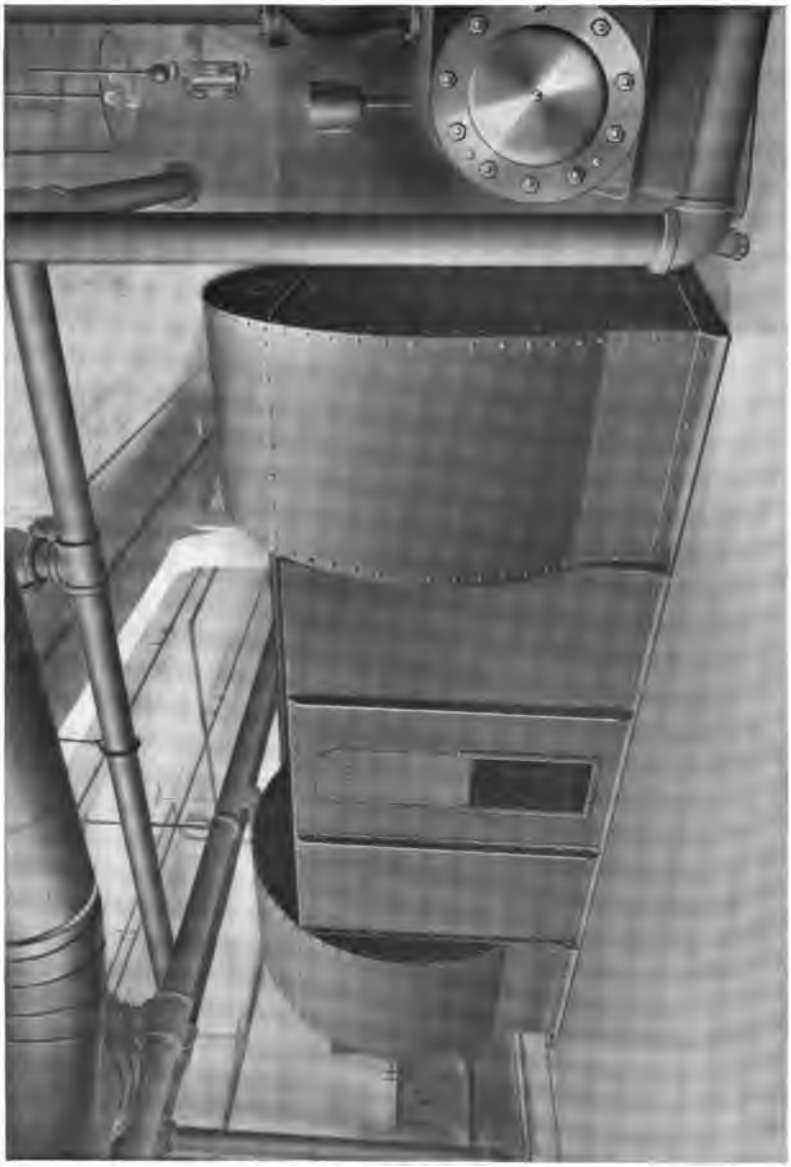

Fig. 28. Sturtevant Heating Apparatus. Bridgeport Car Barn of Connecticut Co., Bridgeport, Conn.

immediate vicinity is so great that they are practically unsheltered from wind and cold.

Tall buildings, as they are ordinarily built, with elevator shafts and stair-cases in the centre running from basement to roof, produce the effect of high chimneys. The air in this open space in the centre of the building rises upward, due to its levity. This naturally makes it necessary to provide extra heat to the lower floors in order to compensate for what is lost by rushing to the top.

102. Determination of Fan Capacity

In the case of a factory or building of similar type, construction and usage, to be heated by the Sturtevant System, the matter of heating is usually considered of most importance, ventilation being secondary. The air supplied to the building is, therefore, introduced at as high a temperature as is desirable, usually about 140 degrees Fahrenheit. The size of the fan necessary to supply the requisite amount of air to maintain the building at a desired temperature is then computed by a knowledge of the amount of heat necessary to supply to maintain this temperature, and in the following manner.

The total number of heat units necessary to obtain the desired temperature in the room is obtained by the use of the coefficients given in Section 98, Chapter VI, in the following manner. The number of square feet of surface of a certain construction is multiplied by the coefficient given in the table by means of which the heat loss through that construction for every degree difference between outside and inside temperature is determined. This is multiplied by the total difference in temperature, giving the total number of B. T. U. lost per hour through this type of construction. By adding the amounts lost through every type of construction, the total heat loss by this means is obtained. Allowance must then be made for loss by leakage of air, exposure or severe weather conditions as further indicated in previous paragraphs. This final total may then be represented by the number of cubic feet of air at a certain temperature, usually 140 degrees Fahrenheit, necessary to supply to a room to make good this loss of heat. The number of cubic feet of air necessary for each individual room in the building having been determined, the total amount which must be supplied by the fan is the sum of these individual quantities.

Only that amount of heat necessary to raise the air from the temperature at which it enters the heater to the room temperature is chargeable to ventilation. In the case of a factory or manufacturing building, where the relative number of occupants is small as compared with the size of the building, ventilation is a matter of secondary importance, as previously pointed out. As it is customary to recirculate any amount up to 75 per cent. of the air of the room, the loss of heat due to ventilation is easily reduced to a very small figure. If air is supplied by the fan directly from outside the entire number of heat units necessary to raise the air from the outside temperature to the desired room temperature will then be chargeable to ventilation.

The relative costs of ventilation and heating with different temperatures of entering air have already been presented.

The method of determining the fan capacity required as stated above is based entirely upon offsetting the heat loss only and is the method generally applied to factory and similar calculations. It should be borne in mind, however, that even with this method in which ventilation is only of secondary consideration, the degree of ventilation obtained surpasses that obtained by any other than the blower system.

For public buildings and the like, where ventilation is of first importance and the vital feature of the system and where the number and activity of the occupants can be determined definitely, the total air supply should be based upon the predetermined provision per occupant.

The general allowances for ventilation in buildings of this class are given in the following table, so that it is only necessary to decide upon the allowance to be made in the given case under consideration and to multiply this by the number of occupants. To this volume, thus determined, must be added the amount to be provided for corridors, cloak and toilet rooms and for apartments not intended for regular occupancy.

BUILDING	CUBIC FEET OF AIR PER HOUR
Hospitals	2,400–3,600 per bed
Hospitals (epidemic) . . .	2,400–4,800 " "
Legislative Halls	3,000 " seat
Workshops	1,500 " person
Prisons	1,800 " "
Churches	1,800 " seat
Meeting-houses	1,200–1,800 " "
Theatres	1,200-1,800 " "
Schools.	1,800 " "
Dining Rooms	1,800 " "

The above values represent average practice but must be used intelligently, as the amount of air necessary under one set of conditions may be entirely inadequate under another. As it is impossible to classify these conditions, the above average values are given.

In many states and cities there are laws governing very definitely the amount of air to be supplied per person in buildings and the frequency of air change to be provided for. These laws should be investigated, and in case they exist, the fan having a capacity sufficient to supply the requisite amount of air or frequency of air change is easily determined.

The aggregate volume to be supplied should be made sufficient for maximum requirements and the system so arranged that proper distribution will be secured where a minimum supply is provided.

103. Determination of Heater Capacity

The total amount of heat necessary, as measured in heat units, having been determined by calculation and the efficiency of the selected form of heating surface being known, it is a comparatively simple matter to decide upon the amount of heating surface required for any given building. But all the conditions must be taken into consideration; the calculations must be made for the minimum winter temperature, the steam pressure made known, and it must be decided whether the air is to be taken entirely from out-of-doors or to some extent returned from the building. As already shown, this latter practice is conducive to economy, but of course is not employed except where heating is the primary object of the introduction of the system, or the normal supply of air is very large per capita.

While quantity of heating surface is of the utmost importance, its arrangement is hardly less important. It is not enough to have a given number of lineal feet of steam coils, or pipes spaced on certain centres, but it is further necessary to have the sections or groups of pipes combined in such form that there may be sufficient free area between the pipes to allow of the ready passage of the air handled by the fan, while the total number of pipes with which a given amount of air comes in contact in its passage through the heater must be such as to secure the requisite rise in temperature of that air. Those who do not possess extended experience in such matters are very apt to arrange their heating surface so as to reduce its efficiency greatly with resulting failure in the heating of the building in which it is installed.

One of the important objects in view in tests that have been made upon Sturtevant heaters by this Company has been to determine definitely the influence of different arrangements of heating surface of the same general character and to ascertain the form in which they are most efficient. This Company is therefore in a position to specify with certainty of the results to be accomplished, the most economical arrangement of the heating surface, thereby decreasing the first cost of the apparatus without impairing or affecting its efficiency.

The performance of Sturtevant heaters is given in charts of Figs. 18, 19, 20 and 21, which are described and explained in Section 79, Chapter V, and in Tables No. 34 and 35.

Presuming that the total number of B. T. U. heat loss from buildings has been calculated, and the total number of cubic feet of air at a certain temperature necessary to offset this loss computed, the heater necessary to supply this heat to the air is determined from Section 79. The amount of air at a certain temperature necessary to supply this heat, its velocity through the heater and its temperature upon leaving the heater being known, the free area required to pass this quantity through the heater is easily computed by dividing the total amount of air per minute by its velocity per minute through the heater. The size of the heater having this required free area can then be chosen from Table No. 34.

Its depth in rows of heater pipe is determined by the charts of Figs. 18 and 19, provided the steam pressure and the temperature of the air leaving the heater have been decided upon and the total number of square feet of heating surface per section of the heater chosen is found in Table No. 34. In case so large a volume of air is handled that the free area through the heaters of standard size is too small, a combination of two or three heaters is used, making it possible to maintain a low velocity of air through the heater.

104. Determination of Boiler Capacity

From a knowledge of the number of units of heat required, or the total weight of steam necessary per unit of time for any given building, it is a simple matter to deduce the size and capacity of the boiler to be provided. A proper understanding of the relative values of high and low pressure steam will result in due consideration being given to this factor in deciding upon the boiler capacity.

105. Distribution of Air

Thorough distribution of air supplied by any system of ventilation is necessary not only in order to obtain the most satisfactory results for mixing fresh air with that in the room but also to prevent objectionable drafts. In halls of audience, where the occupants are inactive, any slight inequality in the distribution is particularly noticeable, while in the workshop, where the occupants are continually in motion and are not in close contact with each other, a less refined arrangement gives satisfaction.

The means by which the distribution of air is accomplished deserves the most careful consideration as, notwithstanding the fact that the fan may deliver a sufficient quantity of air, and that the heater may have sufficient heating surface to supply the required warmth, the effectiveness of heater and fan together or of either separately may be seriously impaired by faulty design in the distributing system.

106. Dimensions of Ducts and Flues

The area of the duct or flue is obviously determined by the volume of air passing through it and by the permissible or desirable rate of flow of the air. Loss due to friction of air on the sides of the duct increases with the square of the velocity of the flow so that if the velocity is doubled, the loss due to friction is increased fourfold. This would seem to make it advisable to move the air at a low velocity; but the size of the ducts will limit the permissible velocity of flow as the increased cost of large ducts will rapidly exceed the saving in power obtained by low velocity. Although the loss in power for increased velocity increases with the cube of the velocity, the common practice of utilizing the exhaust steam in the heater when the fan is driven by a steam engine makes economy of power to drive the fan a consideration of secondary importance. But it should also be borne in mind that there is a minimum velocity of flow and a pressure below which it is impracticable to go because of the inability to provide sufficient ventilation under these conditions. Velocities that may be used in applications of the Sturtevant

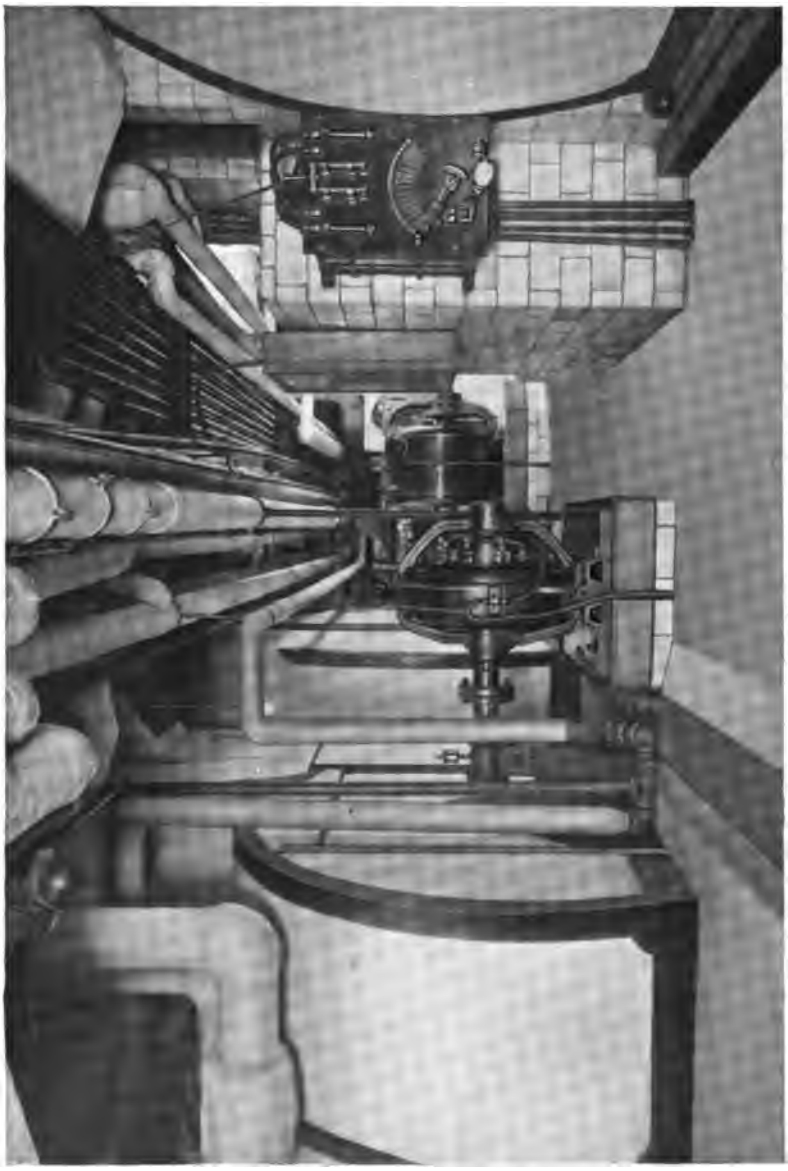

FIG. 29. STURTEVANT VENTILATING APPARATUS. HOTEL ST. REGIS, NEW YORK.

System depend upon the nature of the building, much higher velocity being permissible in factories and mills than in schools or buildings of similar character.

107. Proportioning Ducts and Flues

According to the character of the building two methods appear for figuring ducts and flues. In a manufactory, after determining the fan capacity required and the relative volumes of air necessary for the various rooms, as based upon their cubic content, their desired temperature and their exposure, there may be calculated a constant number representing the square inches of outlet of the fan per 1,000 cubic feet of space (as reduced to a standard of heating to the basis temperature). In a compact system, with a small number of outlets, it is a very common custom to make the aggregate area of these outlets about 25 per cent. in excess of the area of the fan outlet. From this may be determined the square inches of pipe outlet per 1,000 cubic feet of space, and the areas proportioned to the requirements. This excess of area of outlets over the fan outlet demands that the main pipe shall not be reduced exactly in proportion to the outlets taken from it as it extends from the fan, but at such a less ratio that, at the end of the system, the main pipe shall be practically equal to the area of the last outlet or group of outlets.

Table No. 14, explained in Section 108, gives the number of square inches of flue area required for every 1,000 cubic feet of contents for a given velocity and air change.

In schools and similar buildings, where the hot and cold duct system is to be introduced, and the air distribution is to be made proportional to the number of occupants of the individual rooms, the process is practically the reverse. The register or screen area, dependent upon the selected velocity through the same, will be determined by dividing the total volume per minute by the rate of flow per minute. The flue will, in turn, be determined in a similar manner and thus the distributing system will be worked out backward, so to speak, through lines of increasing velocities, to the fan itself. It is very desirable, however, to maintain through the connection at the base of each flue, a velocity considerably higher than that in the flue, in order to counteract all tendency to unequal flow and to render any adjustment of the primary distributing dampers more efficient.

Table No. 12, explained in Section 109, gives the flue area required for a given volume and velocity of air.

108. Flue Area per 1,000 Cubic Feet of Contents

It is desired to deliver 8,000 cubic feet of air at a velocity of 600 feet per minute through a flue which will permit the discharge of this amount of air every 10 minutes. According to Table No. 14, then, the area of this flue must be 24 square inches times 8 or 192 square inches. This table is calculated in the following manner: The area in square feet necessary to allow the passage of 1,000 cubic feet of air per minute at a velocity of 600 feet per minute will be 1,000 divided by 600 which, reduced to square inches, is 240 square inches. This is on the assumption of discharging 1,000 cubic feet per minute. By dividing by the number of minutes in which it is desired to deliver the air, the values of the table are arrived at. According to the example, 240 divided by 10 equals 24 square inches as indicated in the table.

109. Flue Area Required for Given Volume and Velocity

For variable volumes in cubic feet per minute and velocities in feet per minute, the areas of flues in square inches required for passage of air of given volume and velocity are given by Table No. 12. For example, it is required to deliver 800 cubic feet of air per minute at a velocity of 2,200 feet per minute. The area of the flue is 52.4 square inches according to the table. This table is calculated as follows: The area in square feet necessary to pass 800 cubic feet of air per minute at a velocity of 2,200 feet per minute is 800 divided by 2,200 while the area in square inches is found by multiplying the area in square feet by 144, giving the result of 52.4 square inches as in the table. For flue areas for volumes outside the scope of this table, it is merely necessary to use a multiple of the desired volume that is within the scope of the table, the correct answer being obtained by a proper disposition of the decimal point. Thus, if the volume of 8,750 cubic feet is required to pass through a flue at the velocity of 900 feet per minute, the cross section of that flue must be 1,400 square inches.

110. Velocities in Ducts and Flues

In almost all public building installations the definite object of the system is to deliver the air to the rooms at such velocity as to secure its movement to the desired points, but without objectionable drafts or humming of the air as it passes through the registers, which is very likely to occur at velocities of about 1,000 feet per minute. To this end, the average velocity through the net area of the screen or register should not, under ordinary conditions, exceed 500 feet per minute. For average size school rooms, a velocity as low as 400 feet is more desirable, while in small rooms, as in dwellings, this may well be reduced to 300 feet per minute. It is always best to keep the velocity through floor registers, at least, as low as this and preferably lower still. To secure a fairly equable discharge through the full area of the screen or register supplied from a vertical flue, the velocity in this flue should not exceed that through the outlet by more than 50 per cent. Ordinarily, flue velocities in such buildings range from 500 to 800 feet per minute. The rate of flow through the connections to the bases of the flues should, in turn, be higher than that through the flues themselves, while the velocity in the main horizontal distributing ducts should even be higher still. In fact, in buildings of this class, the plan should be to reduce gradually the velocities from the point of leaving the fan to the point of discharge to the rooms. Careful investigation has shown that, everything considered, the velocity in the main horizontal ducts from the fan should not be below 1,500 feet and preferably 3,000 feet per minute.

In case of a manufactory, or wherever rooms are of excessive size, the treatment should be radically different. Here a high velocity is necessary to assure the passage of the air to the most distant points. It is not at all infrequent in such buildings to force the air 100 to 200 feet from the outlet. The conditions which will permit of such air movement will be made more evident in succeeding illustrations of the system as applied to manufacturing establishments. A high velocity at the discharge outlet is evidently necessary to force the air for such a distance through the open room. Very slight increase is made, therefore, over the area of the fan outlet. As the fan in such a building usually operates at high speed, the air leaving its outlet at a velocity of about 3,500 feet per minute, even a fairly generous increase in areas will maintain its discharge through the flue outlet at velocities of from 2,000 to 3,000 feet per minute.

Of course, with such high velocities, the frictional losses are increased; but the fan being operated at higher speed, the proportional losses are not excessive, while the rapidity of movement reduces the time during which the moving air within the conduits may part with its heat.

111. Design and Construction of Ducts and Flues

Too much care cannot be taken to insure the most advantageous design of the ducts and flues in heating and ventilating installations, as the satisfactory operation of the apparatus depends very largely upon the proportion of these parts. Owing to the small scale upon which most heating and ventilating arrangements must be drawn and the general lack of detail drawings for individual features, the galvanized iron worker and the mason are often left to a considerable extent to their own devices to accomplish the desired results. With men especially experienced in work of this nature, there will be little trouble, but the ordinary tinsmith and mason undertaking the construction of ducts and flues are apt to spoil the effectiveness of a well designed system by improper attention to general details.

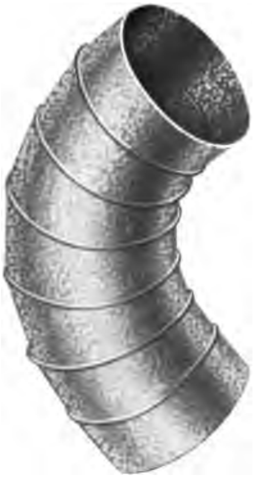

FIG. 30. ELBOW.

Because of the enormous amount of resistance which is offered by sudden and sharp bends or turns in a flue or duct even in a system so well proportioned by the designer that the loss by friction has been accounted for, the introduction of stove pipe elbows will have a disastrous effect. In galvanized iron pipe, turns of 90 degrees in direction should be constructed with at least 5 pieces and with a radius of curvature on the inner side of the elbow at least equal to the diameter of the pipe. (See Fig. 30.)

Branch pipes butting squarely into a main pipe are a great source of unnecessary friction, and it may prove practically impossible to get the calculated flow of air into such a pipe. Branches should lead from main ducts at an angle as shown in Fig. 31, so that the direction of the flow entering a branch elbow will not be changed suddenly. Wherever it is necessary to change the size of the pipe, this should be done by a gradually tapering connection, similar to that of Fig. 31, whether the pipe be square or circular in cross section, this form of construction offering the least resistance to the flow of air. In dividing a main duct so as to discharge in two directions, the branch con-

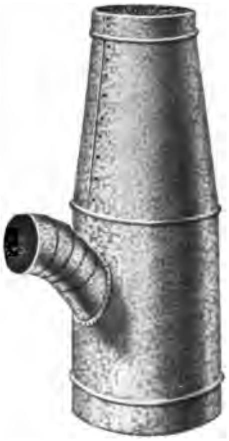

FIG. 31. BRANCH.

nection should be constructed so as to divide the air currents proportionally, as in Fig. 32.

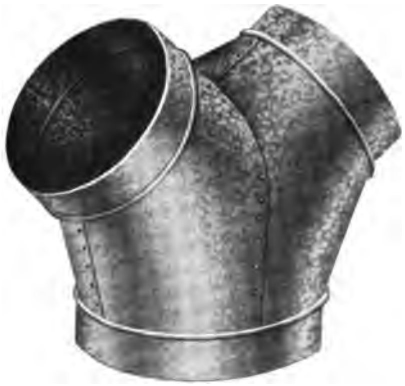

FIG. 32. "Y" BRANCH CONNECTION.

The acute angle formed by the two branches should be utilized to split the air volumes, thus compelling the air easily but positively to change its direction. In reality, the reduction in size of pipe beyond the branch is made in the branch, and by its arrangement, serves to catch and deflect the requisite amount of air. Pipe of this form of construction is largely built for school house and similar installations where it is generally suspended from the ceiling of the basement. It is usually rectangular in form so as to be economical of space and head room.

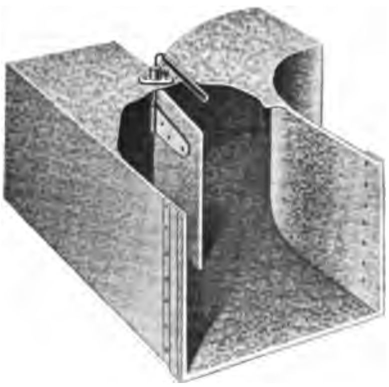

FIG. 33. DEFLECTING DAMPER.

Where a division in ducts is accompanied by unequal resistances beyond the point of division on account of differences in areas and lengths, it is best to provide some additional means by which the flow of air into the branch pipes may be permanently equalized after the system has been installed and placed in service, as the exact values of these various resistances cannot be always definitely predetermined. To this end, all branches such as shown in Fig. 33 should be equipped with simple deflecting dampers which may be regulated from the outside and permanently held in any desired position. With such an arrangement, the amount of air delivered to any branch may be easily regulated after the system has been placed in commission.

112. Weight of Galvanized Pipe

As already stated, galvanized steel is almost exclusively employed for the making of large pipes, ducts and flues for conveying air. Its non-rusting qualities, and the large size of the sheets in which it may be purchased, make it, by all means, the best suited material for this purpose. Although straight round pipe is frequently sold by the running foot, the ordinary practice in work at all complicated, as in the case of heating and ventilating systems, is to base the price upon the weight, the rate being at a given amount per pound. As prices have to be made in advance, it is evidently necessary that one should be able to estimate accurately and with comparative ease from a drawing the amount of material required.

To aid in such calculations, Table No. 17 has been prepared, giving not only the weight of the galvanized steel per square foot, but also the weight per running foot for round pipe and the weight of elbows of corresponding sizes. This table may be relied upon as giving the maximum weight. Allowance having been made for laps and trimmings as well as for rivets and solder, the general waste, for obvious reasons, cannot be included. The elbows are of the standard type previously described, having the internal radius of curvature equal to the diameter of the pipe itself.

In ordinary heating and ventilating practice, it is customary to make round pipe in its various sizes upon gauges as follows: Under 9 inches, No. 28 gauge; 9 to 14 inches, No. 26; 15 to 20 inches, No. 25; 21 to 26 inches, No. 24; 27 to 35 inches, No. 22; 36 to 46 inches, No. 20; 47 to 60 inches, No. 18, and all sizes above 60 inches of No. 16 gauge. If the pipe is made much lighter, particularly in the larger sizes, it will not keep its shape when laid horizontally, thereby seriously affecting the tightness of the joints and decreasing the area.

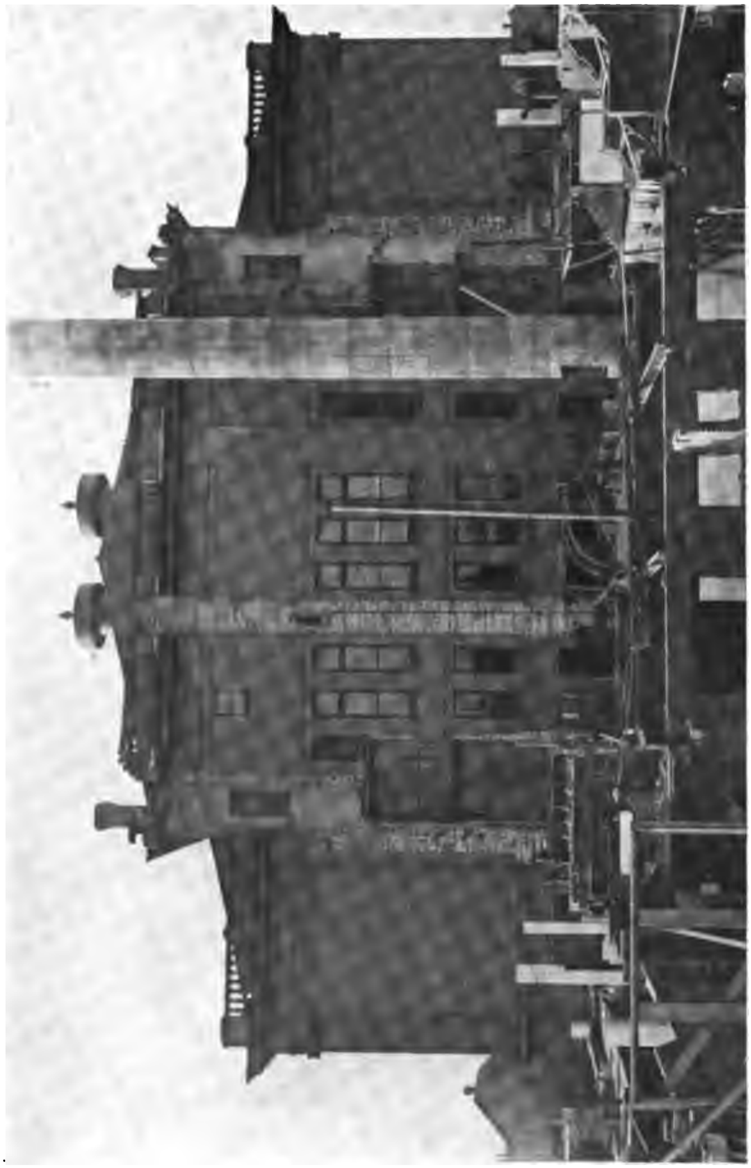

Fig. 34. Lincoln High School, Hibbing, Minn., showing Wall Flues in Course of Construction.

The common practice is to make rectangular pipes of the same gauge as round pipes having an equivalent area, but under certain conditions, as in the case of thin, flat pipe for overhead distribution, bracing is necessary to prevent the top and bottom from sagging even with heavy gauges. Therefore, with the bracing, gauges lighter than the ordinary may be used.

In calculating the weight of rectangular pipe, its superficial area, *i. e.*, its perimeter in feet, multiplied by its length in feet is taken as the basis, and special shapes are figured in a similar manner. The laps in rectangular pipe require more stock than in round pipe, and therefore from 10 to 25 per cent. is added, according to the character of the pipe, to allow for this excess of material and for the weight of the necessary bracing and ribbing.

113. Brick Ducts

In the construction of brick ducts and flues, the same principles should be observed as in the construction of galvanized steel piping. Sharp bends and sudden reductions in area must be avoided. Brick work should be as carefully finished on the inside as is practicable, since roughness of the sides increases the frictional losses. Where the expense will permit, it is wise to line the interior of the flues and ducts with sheet metal or with terra cotta flue linings made for this purpose. In Fig. 34 the heating flues can be seen in course of erection. It will be noticed that these are of galvanized steel built into brick flues in the walls of the building and erected at the same time with them. Underground ducts are universally made of brick or concrete in the larger sizes and glazed tile piping is used for smaller ones. Hollow tile may be used in place of brick, the dead air spaces providing excellent heat insulation.

114. Concrete Ducts

In place of brick, concrete is often used for constructing flues and ducts for conveying heated air. Concrete ducts can be made over forms, cheapening the construction considerably and they may be insulated against excessive heat loss by introducing dead air spaces. Inside they should be finished as smoothly as possible to reduce friction by a coating of neat cement or by a galvanized steel lining. In proportioning concrete ducts and in constructing branches, turns and bends, the same general rules apply that have been given for brick and galvanized steel construction.

115. Arrangement of Ducts and Flues

In arranging a system of ducts and flues within a building, the method of distributing the air and the construction of the building must be carefully considered. In brick and concrete buildings, flues may be easily and economically built in the walls when the building is originally erected. Because of this, it is generally desirable that the arrangement of the heating and ventilating flues be made before the building is erected, as both economy and sightliness can then be obtained. Where this is neglected, it is necessary either to resort to expensive alterations or to impair the appearance of the buildings.

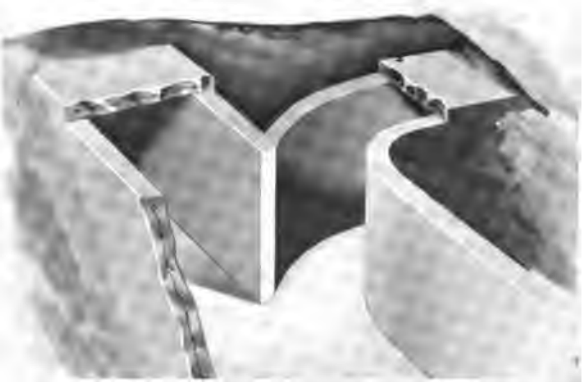
FIG. 35. BRANCH IN UNDERGROUND CONCRETE HEATING DUCT.

In an old building, metal ducts and flues are almost a necessity, the material generally employed being galvanized steel. In such buildings, flues and ducts can be introduced without marring the general appearance, for it is a simple matter to work them in as columns, cornices, beams or ornaments, or to introduce perforated ceilings without attracting attention. The galvanized steel is so covered by decorative material that it does not present an inharmonious appearance.

116. Ventilating Flues

To obtain the best results, ventilating flues should be carried separately above the roof where the discharge may be protected by a covering in the form of a pent house with louvred sides. When the exhaust fan is used in connection with ventilating flues, as is usually desirable and often necessary because of the complicated nature of the building, it should be connected directly to the flues. An exhaust fan simply drawing from the attic space and discharging out-of-doors will prove very inefficient, owing to the ease with which a portion of its supply will find its way by leakage through the roof rather than from the rooms below. As a result, the fan performs only a portion of the work of ventilating the building.

117. Heating Flues

For the heating of manufacturing buildings which are several stories in height, such as textile mills and machine shops, convenient arrangements of distributing flues are shown in Figs. 36 and 38. As will be noted, these flues are in the wall of the building. Two general arrangements are shown.

By building pilasters of brick upon the outside of the building, flues may be concealed within them. The flues, having openings for discharging air onto each floor, receive air from a duct in the basement, which in turn is filled by the heated air from the fan. Suitable dampers of a design shown in Fig. 37 regulate the volume of air discharged into the building from each flue and, at the same time, act as deflectors.

These flues are situated on one side of the building and discharge air directly across the room. In manufacturing buildings, moving belts and pulleys sufficiently break up the air currents to distribute the air to all parts of the room. Although, conditions permitting, it is usually advisable to place the flues upon the least exposed side of the building discharging toward the colder side, nevertheless, in practice, the effect of location of flues is seldom perceptible in such a structure.

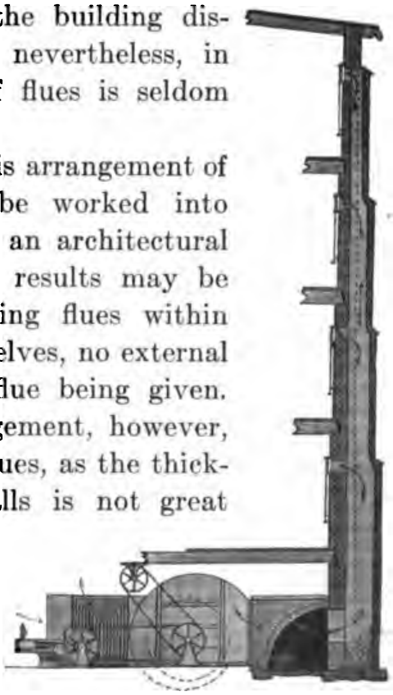

FIG. 36. WALL HEATING FLUE.

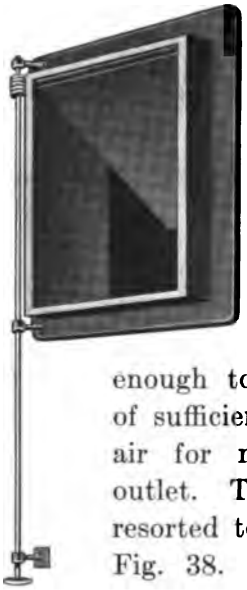

FIG. 37. DAMPER.

Although this arrangement of pilasters may be worked into the building as an architectural feature, similar results may be obtained by using flues within the walls themselves, no external evidence of a flue being given. Such an arrangement, however, requires more flues, as the thickness of the walls is not great enough to provide a flue of sufficient size to carry air for more than one outlet. The arrangement resorted to is indicated in Fig. 38. This construction is, of course, more costly than the former and gives opportunity for greater loss of heat, although this loss may be greatly reduced by the use of flue linings. Both of these arrangements make possible the heating of the building from one side only and require no galvanized steel piping system.

118. The Stand-pipe Method of Distribution

A method of air distribution often employed in factories and mills is the so-called " stand-pipe " method. This is clearly illustrated in Fig. 39. Other and different arrangements of this same system are used.

For this method of distribution, a vertical stand-pipe, having branches discharging horizontally in all directions, is run through the building from one floor to the next. This system of distribution calls for no overhead piping and therefore may be installed without interference with belts and shafting. Placed in the centre of the floor space and discharging toward the outer walls, a thorough diffusion of air is provided. The velocities used in this method of distribution are necessarily high because the air must be forced a considerable distance from the outlets. Stand-pipes are generally built of galvanized steel with short galvanized steel distributing pipes discharging above the head level. A guard of steel plate is placed about the lower part of the stand-pipe to prevent denting and other accidents to it.

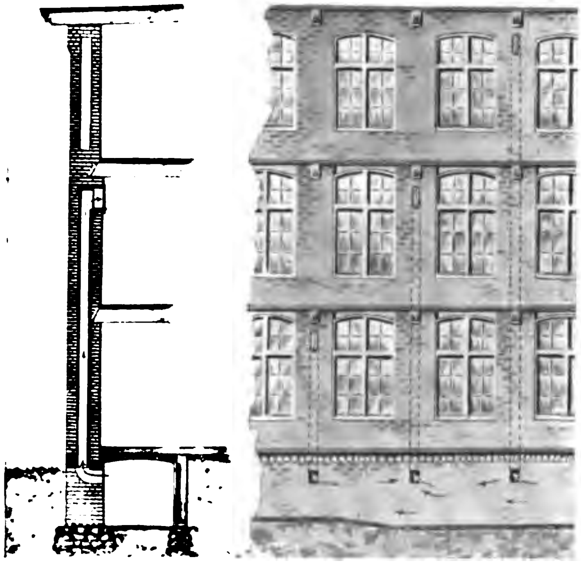

Fig. 38. Heating Arrangement. Wall Flues and Duct.

119. Location of Registers

The same method of distributing air cannot be applied to all ventilating problems. Air entering the rooms from the heater being at a higher temperature than the air and the objects in the room, will be cooled by passing through it. It will, therefore, best serve its purpose as a means of heating and ventilating if it is admitted to the room at a point most distant from the outer wall. Thus heated, the air, leaving the register in the upper part of the wall, is diffused over the top of the room and is cooled by passing through it and by contact with the relatively colder exterior wall until it sinks to the lower part of the room. Where a building such as an office, school or an apartment has interior partition walls, this arrangement is easily introduced because flues may be located in or against these interior walls. To complete the circuit of the ventilating air through the room, and to fulfil the design, a ventilating register should be placed in the same inner wall as the supply, opening close to the floor. There is thus induced toward this outlet a return flow of vitiated air. In the placing of heating and vent flues, considerable care must be taken to avoid short circuit, that is, to prevent the air entering the room from flowing directly to the vent flues before it has an opportunity to diffuse through the room. In certain classes of buildings, it is sometimes practicable to provide a reversible system so that warm air is admitted near the ceiling in the winter, vitiated air being removed near the floor, and cool air is admitted in summer near the floor, the warmer, vitiated air being removed near the ceiling.

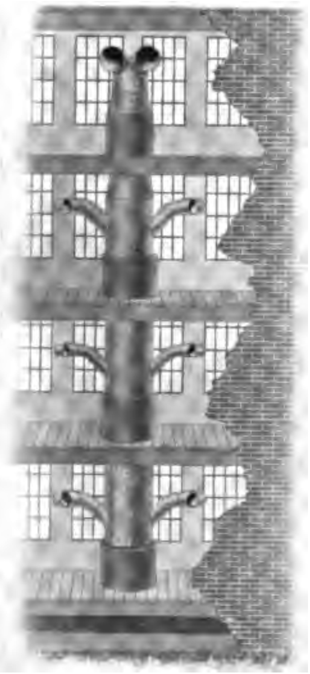

FIG. 39. STAND-PIPE HEATING FOUR FLOORS.

It has been shown experimentally that a velocity less than 95 feet per minute is not perceptible, and that a movement of air as high as 180 feet per minute is not objectionable. The temperature and humidity of the air in a room affect very greatly

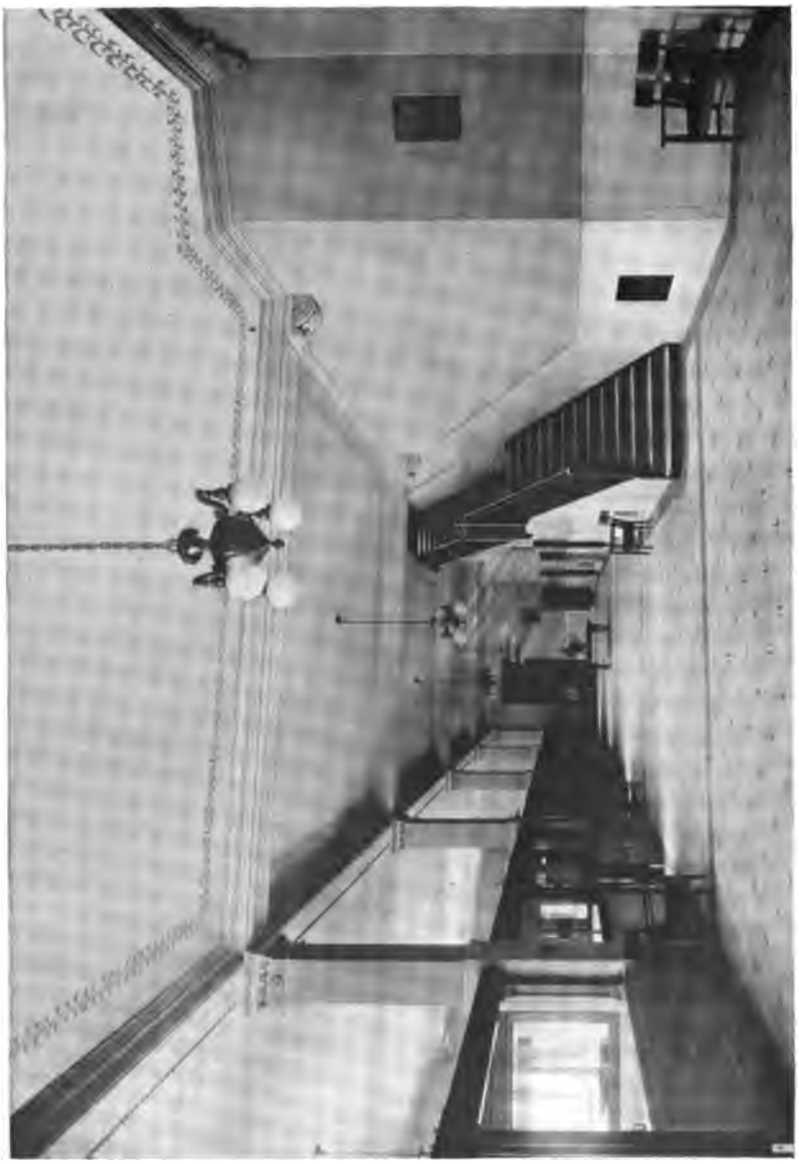

Fig. 40. Offices John B. Stetson Co., Philadelphia, showing Heating and Ventilating Registers in the Wall.

the sensitiveness of the body to drafts. In designing distributing systems, care should be taken to locate the registers so that no movement of air greater than 180 feet per minute strikes directly upon the occupants.

120. Floor Outlets

Air, for ventilation in theatres, churches and halls, where the occupants are numerous and close together, is generally admitted through the floor, the movement being upward. In such places, the animal heat generated by the occupants is sufficient to increase materially the temperature of the room and to produce a direct upward movement of the air. Under such conditions, ventilation is obviously more necessary than heating and the air is consequently admitted at a comparatively low temperature. In theatres, it is generally desired to provide as much individual ventilation as is practicable, and on this account, air is admitted through the floor by means of openings in the chair legs or small outlets in the floor. The exit for the air from the room is provided in wall registers and openings in the ceilings which connect with flues and, in most cases, with exhaust fans.

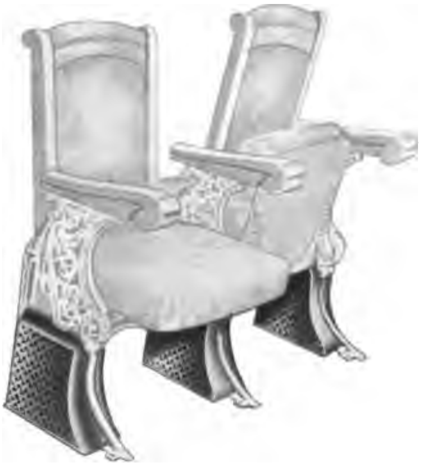

FIG. 41. THEATRE CHAIR VENTILATORS.

A type of chair leg outlet is shown in Fig. 41, where the casting which forms the leg of the theatre chair is hollow and latticed so that the air, entering from the plenum duct below, is discharged through the openings immediately above the floor. The air, passing through the floor openings at relatively low velocities, is permitted to escape into the audience room with a low and imperceptible movement and then to pass upward to the ceiling vents.

Another type of floor ventilator is shown in Fig. 42 and consists of a special casting made to fit in an air outlet in the floor. This outlet is covered by a cap which, in many designs, is adjustable so that the flow of air through it may be regulated. The function of the cover is to permit the air to flow from the opening at a low velocity and to spread it out horizontally over a large area so as to diffuse it rapidly into the atmosphere of the audience chamber. Being covered, there is no direct blast perceptible to the occupants. The wide distribution of the blast so reduces its velocity that objectionable drafts along the floor are not noticeable.

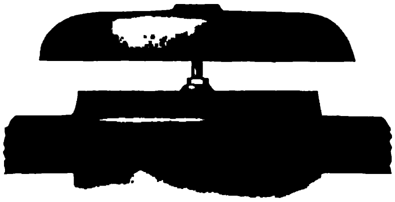

FIG. 42. FLOOR VENTILATOR.

121. Hot and Cold System

It is evident that the discharge of the fan may be so divided that part of it will pass through the heater and the remainder through a by-pass around the heater. The air passing through the heater, then, is at a higher temperature than the air which is by-passed around it, and if varying proportions of the warm and cool air are rightly mixed, the temperature of the resulting mixture can be easily controlled. A heater arranged for discharging warm and cold air is shown in Fig. 23.

In buildings where careful regulation of the temperature is necessary, the influence of exposure to wind and sunlight, of location, whether on the north or the south side of the building, and countless other conditions, many of which can be determined only after the system has been installed, make it necessary to regulate carefully the temperature of the incoming air. Moreover, as ventilation in these buildings is generally a matter of considerable importance, it is always desirable that the temperature of the room should be controlled by the volume of air entering.

It is in such conditions as these, that the hot and cold system is most generally used. As it is obviously impossible to maintain the desired temperature in every room by regulating the temperature of the supply of air at one point, the discharge of the fan, a system of distribution known as the double duct system is employed for carrying to the bases of the flues and discharging into the various rooms both warm and cool air. Here, as is explained in Section 122, the warm and cool air are admitted to the flue in varying proportions, determining the final temperature of the room. The double duct itself, whether built under the ground of brick or concrete, or constructed of galvanized steel, as is generally the case in school house heating installations, provides two distinctly separate ducts, one over the other. Where the installations of two ducts will prove too expensive, because of the arrangement of the building, a double plenum chamber is often substituted and single ducts run to the flues. The advantage of individual control of every room is maintained without the construction of a large double duct, as is necessary in the double duct system.

122. Mixing Dampers

A type of distributing system known as the double duct, described in the preceding section, makes it possible to regulate the temperature of the air admitted to the various rooms without affecting the volume supplied. Two methods of regulation appear: First, that by which full volumes of cold and warm air are alternately admitted, and second, that by which a damper is so constructed and adjusted as to permit the air of the two temperatures to produce a constant mixture of the desired temperature. If by the first method alternations are sufficiently rapid, the room is maintained at a practically constant temperature, but if less frequent, the tendency is toward fluctuations between extremes, although the proper average may be maintained.

Obviously, the first type of damper is impracticable for operation by hand, for it would require constant attention. For hand regulation, the second type must, therefore, be adopted, and for perfect action, it must so admit the air volumes relatively to each other that one shall be decreased proportionally as the other is increased, and thus cause the volume to remain constant. This requirement is met by the Sturtevant mixing damper, which, being of cylindrical form, of necessity fulfils this function. As ordinarily arranged for hand regulation, it is shown in Fig. 43, in connection with a system of overhead ducts suspended just below the basement ceiling. The damper proper swings in a cast iron frame, which may be bricked into the wall, and to which the double system of ducts may be connected. From the cylinder, which is pivoted as shown, there extends up the flue a chain which, after passing over the guide pulley, is conducted into the room at some three or four feet above the floor, there to be operated at the will of the occupants.

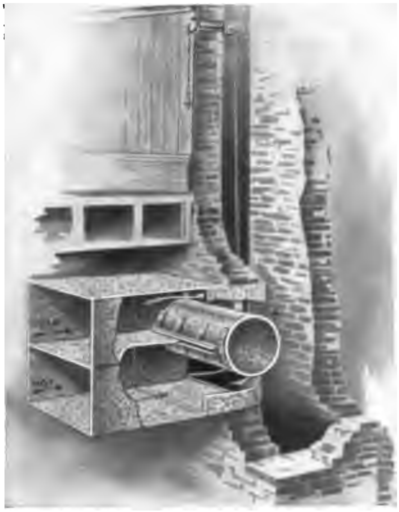

FIG. 43. HAND CONTROLLED MIXING DAMPER.

Although the temperature of a given apartment may be maintained very near a stated temperature by such means, the mixing damper, under certain conditions, may require such attention that some other than human agency is desirable for its operation. This part is played, and most perfectly too, by the thermostat, which, operating under the influence of the variations in temperature of the room, acts to produce converse action of the mixing damper. That is, as the room temperature increases, the volume of cold air admitted is increased, while the warm air is correspondingly decreased.

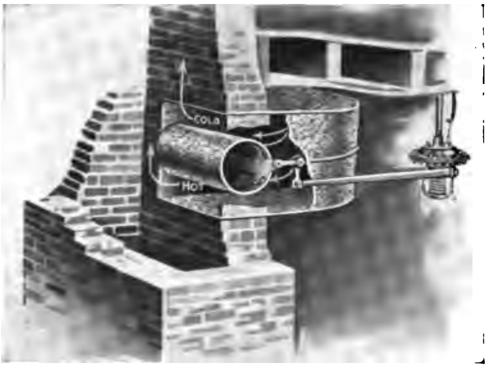

FIG. 44. MIXING DAMPER, THERMOSTATIC CONTROL.

When regulation of temperature is to be secured by a maintained mixture of the hot and cold air, the type of damper previously illustrated is employed. In Fig. 44 is represented such a damper operated gradually by a thermostat acting through a system of levers. With such a type of damper, it is possible to supply, through the cold air duct, air that has acquired no heat other than that taken up in its passage through the duct to the damper. But, if so supplied, the damper must be capable of shutting it off completely, if occasion demands that a full supply of warm air only shall be delivered to the room to maintain the desired temperature. This is attained in the Sturtevant mixing dampers by packing the cylinder with felt in such a manner as to prevent all leakage of cold air when closed against its supply.

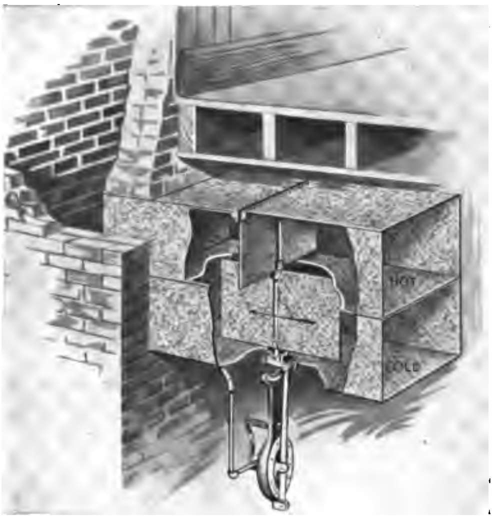

FIG. 45. THERMOSTATICALLY CONTROLLED MIXING DAMPER.

For intermittent operation, the type of damper shown in Fig. 45 is frequently employed. This consists merely of two straight butterfly dampers set at right angles to each other, so that when one is closed the other is open. Naturally with a damper of this description, operating to admit cold and warm air alternately, the relative temperature of the cold air should be only a little below that of the room to which it is supplied, for otherwise, too sudden cooling and objectionable drafts would be created. It is necessary, therefore, under these conditions to provide, in connection with the main apparatus, a tempering coil through which all of the air shall pass, and from which volume the supply for the so-called air duct shall be taken.

A damper of this type is not desirable for gradual adjustment where a constant mixture is maintained, first, because it is inherently incapable of keeping the total volume constant within varying relative volumes of hot and cold air; second, because, as it is ordinarily constructed, it does not shut tight against the cold air supply.

123. Temperature Control

In the Sturtevant System of heating, there are three general ways in which the temperature of the building may be controlled.

1. By regulating the amount of heated air supplied.
2. By mixing varying proportions of hot and tempered air by means of mixing dampers, so that the temperature of the entering air is under control.
3. By regulating the temperature of the heater coils and hence the temperature of the air supply passing through them.

124. Temperature Control by Regulating Amount of Supply

Where the chief object of the Sturtevant System is heating and where ventilation is unimportant, or only incidental, the temperature may be controlled by varying the volume of the heated air supply. In many factory and round-house heating installations this method is used. Volume dampers, set in the outlets of the hot air pipes, are used to control the volume of the air supply. These may be easily operated by the workmen themselves. This method of regulation is simple and is aptly suited to the class of buildings in which it is used. It should never be installed where ventilation is an important consideration, as such great variations in the volume of air supply as it naturally causes would make ventilation uncertain.

125. Temperature Control by Air Mixture

In order to regulate the temperature of the air supply without affecting the volume, mixtures of air at two different temperatures can be obtained by the use of mixing dampers. In ventilating systems in public buildings, schools and theatres, both a heater and a tempering coil are used. Some of the air from the tempering coil can therefore be by-passed around the heater so that air at two temperatures is available. Various methods of utilizing this principle present themselves.

The tempered and the hot air may be mixed at the outlet of the heater resulting in a supply of air at one temperature. By varying the relative amounts of hot and tempered air by means of mixing dampers, the temperature of the resulting mixture can be accurately determined. Section 126 deals with the various proportions of air at differing temperature necessary to obtain a desired temperature of mixture.

If it is desired to regulate individually the temperature of the air supplied to each room, a double plenum chamber or double duct system may be used in connection with a system of piping providing for an individual air duct to each room. Dampers located at the entrance to the ducts from the double plenum chamber, control the relative volumes of hot and warm air without affecting the actual volume of the mixture delivered, but instead of controlling the temperature of the entire building by one set of mixing dampers, an individual set of mixing dampers is provided for every room so that the temperature of the air

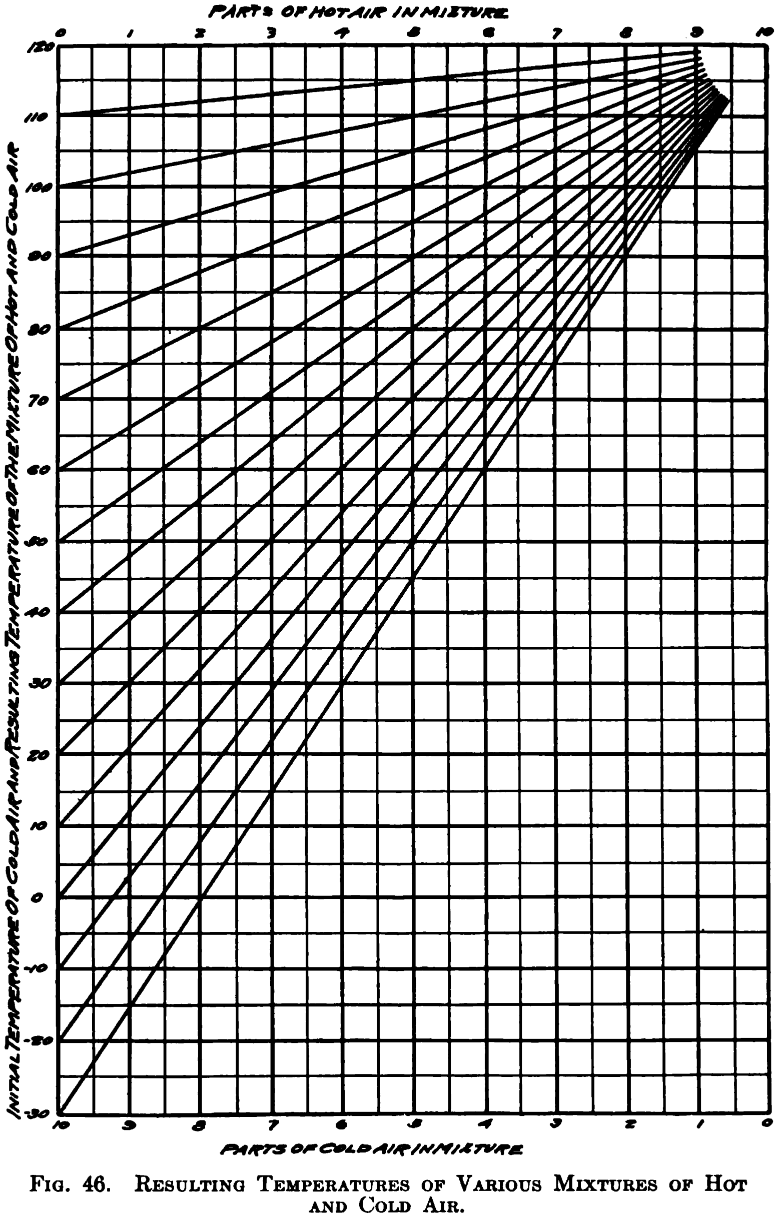

FIG. 46. RESULTING TEMPERATURES OF VARIOUS MIXTURES OF HOT AND COLD AIR.

entering that room may be regulated independently of the other rooms of the building.

These mixing dampers may, of course, be hand-operated, in which case they should be under the charge of a competent caretaker or janitor. A much better way, however, is to resort to an automatic thermostatic control such as is described in Section 128.

126. Mixtures of Hot and Cold Air

For calculating accurately the resulting temperature when two volumes of hot and cold air of given temperatures are mixed, it is necessary to take into consideration the temperature, weight and humidity of these volumes; but in estimating and for purposes of comparison, the difference in weights and the humidity may be disregarded.

Considering temperature alone then, if, of a stated resulting volume of air, 4 parts are at a temperature of 30 degrees and 6 parts of 120 degrees, the resulting temperature of the mixture will be 84 degrees, or $\frac{(4 \times 30) + (6 \times 120)}{100}$. By similar calculation, the chart of Fig. 46 has been laid out to show the relative mixtures and resulting temperatures under the given conditions. One hundred and twenty degrees has been taken as the initial temperature of the hot air. The cold air figures refer to the temperature of the air as it passes through the mixing damper. What its temperature might have been before entering the apparatus must depend largely upon the arrangement of the system and the total amount of cold air passing through the apparatus at the time. The vertical lines upon the diagram represent the relative proportions of hot and cold air as indicated by the figures at the bottom, while the horizontal lines serve as measures both of the initial temperature of the cold air and the resulting temperature of the mixture, which latter may be read from the diagonal lines ending in the given initial temperature of the cold air. For instance, the temperature of the mixture of 3 parts of cold air of 20 degrees and 7 parts of hot air of 120 degrees temperature may be read at the intersection of the diagonal from point 20 on the left, and the vertical from point 3 for cold air and 7 for hot air on the base line below.

127. Temperature Control by Regulating the Temperature of the Heater

For automatic regulation of temperature, an economical means may be found in regulating the amount of steam supplied to the heaters, and hence the actual temperature of air passing through it. This is accomplished as indicated in the following section. This naturally controls the temperature of the entire supply as a whole and is not applicable where individual control, independent of other rooms, is desired.

When it is desired to control the temperature of a room independently of every other room by regulating the steam supply, additional radiation may be placed in the stacks or flues supplying rooms where additional heat is required. By regulating the temperature of this coil thermostatically, the temperature of the incoming air may be varied. By placing direct radiation within the room itself, additional heat may be secured. This is often done where rooms or hallways are severely exposed and where more heat is needed than is necessary in other parts of the building.

128. Thermostatic Control

There are various systems of thermostatic control upon the market, many of which are applicable for use with the Sturtevant System. The pneumatic or compressed air system is the most generally used and the most reliable. This consists, essentially, of a thermostat, a complete system of compressed air piping and regulators operated by compressed air.

The thermostat consists of a valve which is opened and closed by the expansion and contraction of a metal spring, per-

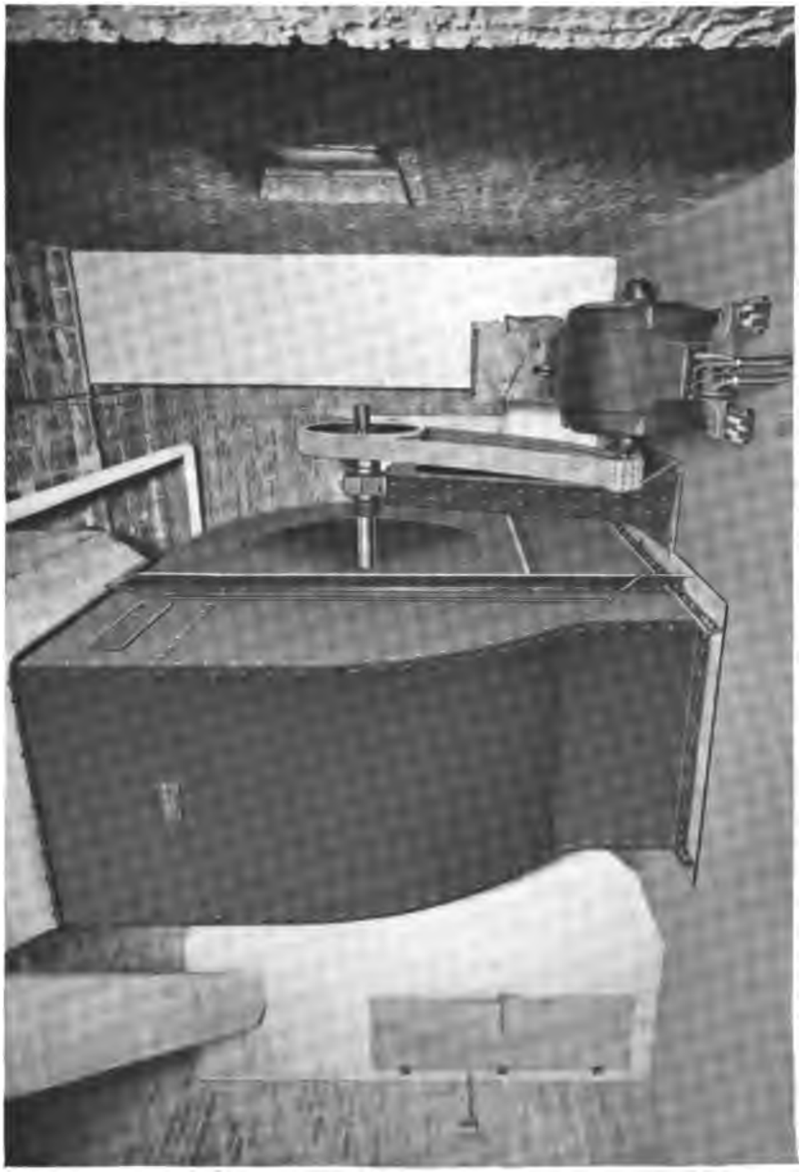

Fig. 47. Sturtevant Ventilating Apparatus, Medinah Temple, Chicago, Ill.

mitting, with varying temperature, a passage of compressed air through the piping system to the regulator. Acting upon one side of the rubber diaphragm in the regulator and against the resistance of a spring, the compressed air causes the diaphragm to move either outward or inward, according to the pressure it exerts. This motion is transmitted through a proper system of levers to the mixing dampers, so that with a variation of temperature in the room containing the thermostat, there is a movement of the dampers regulating the proportions of hot and tempered air supplied to that room.

These compressed air regulators are also made for attaching directly to steam valves for controlling the amount of steam admitted to heater or radiator. The thermostat is usually provided with a regulating device which can be adjusted so that the temperature of the room is maintained at any desired degree within reasonable limits. Compressed air for the system is stored in a tank and is supplied by an air compressor, generally motor driven and automatically started and stopped by a controller regulated by variations of pressure within the tank.

129. The Design of Heating and Ventilating Systems

It must appear from the preceding pages that the proper design of a satisfactory system of heating and ventilation is no simple matter. It is neither a question of theory nor of practice, the one independent of the other, but such a comprehensive knowledge of the entire matter is necessary that certainty of result may be assured. As the demands for improved ventilation have increased, the problem has grown more and more complicated, until it has become an evident fact that no public building of reasonable size should be trusted to other than an expert of established reputation.

CHAPTER VII

TESTING

130. Testing Heating and Ventilating Apparatus and Systems

It is often necessary to test heating and ventilating apparatus after it has been installed in order to determine if the engineer or contractor has lived up to his guarantee or to discover if the system is performing its duty properly. It then becomes necessary to have a clear understanding of the technical aspects of the ventilating problem and to have clearly in view the laws governing the flow of air, the relations between velocity, pressure and power, and the instruments used in making the tests.

The following paragraphs are incorporated, therefore, for the information of the reader who finds it necessary to use these fundamental principles dealing with the testing of systems.

131. Measurement of Air Volume

The amount of air in cubic feet per minute flowing through a pipe or duct may be measured with a close degree of accuracy. The method to be employed will depend on the degree of accuracy desired and the arrangement of the system to be tested. The two methods generally employed are the anemometer and the pitot tube methods.

132. The Anemometer

The anemometer, shown in Fig. 48, consists of a light and delicately constructed fan wheel whose motion is transmitted to a system of practically frictionless gearing within an attached case. Upon a dial, the movement of the fan wheel is registered by hands revolving over graduated circles, and the velocity of the air in feet per minute is thus indicated.

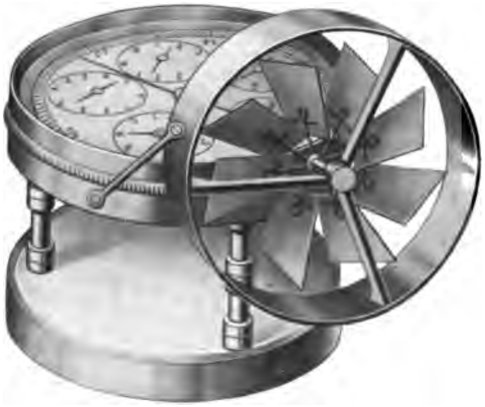

FIG. 48. ANEMOMETER.

By moving the anemometer slowly over an outlet through which air is discharged, the fan wheel, being held perpendicularly to the direction of the flow of air, is revolved by the action of the moving air against its blades. The time is noted, the dial read and the velocity of air ascertained. Evidently, the velocity thus obtained, corrected for any known error of the instrument, multiplied by the area of the passage, must give the volume of air passing.

133. Anemometer Reading

Where great accuracy is required, the anemometer should not be used unless it is impossible to measure the velocity of air by more accurate means. It is necessary to correct all readings by means of a factor determined for that particular instrument by experiment. No two anemometers read alike, and this factor of correction is therefore a necessity.

The anemometer is practically the only means of directly measuring the discharge of air through a register. When used, it should be moved slowly and at uniform speed over the face of the register so as to obtain an average reading for the velocity and not one that is either too low or too high.

134. The Taylor Pitot Tube

As pointed out before, both the pressure head and the velocity head have to be taken into account in measuring the velocity of the flow of air. In order to separate these two factors of the total head, a form of pitot tube known as the Taylor pitot tube (see Fig. 49) is used. Two tubes, concentrically placed within one another, are introduced into the pipe or duct in which the air is moving and are turned parallel to the direction of flow so that the moving air impinges against the end of the tube. The inner tube, having an open end, receives the full force of the impact, and, if connected to a gauge, will register both pressure and velocity head, or the total head. The end of the outer tube is closed, however, and a slot is provided in the wall of the tube so that if this tube is connected to a gauge, only the static or pressure head will register. If, now, the inner tube be connected to one arm of a differential gauge, while the other is connected to the opposite end, the head registered by the gauge will be the difference between the total and the pressure head, or, in other words, the velocity head, as both arms of the gauge are subjected to the same pressure head which is therefore balanced.

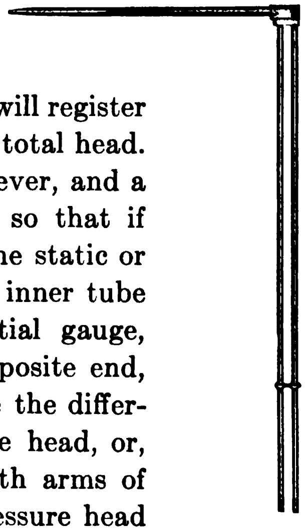

FIG. 49.
PITOT TUBE.

135. Measurement of Velocity by Pitot Tube

In Fig. 50, " S " shows the flexible connection from the pitot tube measuring the static pressure or pressure head, while " I " shows the connection measuring the impact or total head. "S" is recorded on the U tube gauge and also neutralizes the effect of the pressure head recorded with the velocity head in the total or impact head so that velocity head is measured directly in inches of water on the differential draft gauge scale. In this manner both the velocity and pressure head can be measured at the same time. One gauge could, of course, be used for both of these measurements. Simultaneous readings could not be taken, however, and as a variation in fan speed or resistance would affect both the pressure and velocity heads, the readings obtained in this manner might be inaccurate.

136. The U Tube Gauge

The pressure exerted by moving air in a duct or pipe is usually measured by the difference in level of a liquid in the arms of a U shaped tube having one end open to the atmosphere and the other connected to the duct or pipe within which the difference of pressure exists. (See Fig. 51.) The preponderance of pressure in one arm forces the liquid downward and causes a corresponding rise in the other. The difference in level represents the height of a column of the liquid which will be sustained by the excess of pressure. The liquid usually used in gauges employed in ventilating work is water. One cubic foot (1728 cubic inches) of water at 50 degrees Fahrenheit weighs 62.409 pounds. Therefore, a column of water of this temperature 1728 inches high and 1 inch cross-sectional area would exert a pressure of 62.409 pounds per square inch. The height of a column necessary to produce one pound presents $\frac{1728}{62.409} = 27.7$ inches. From

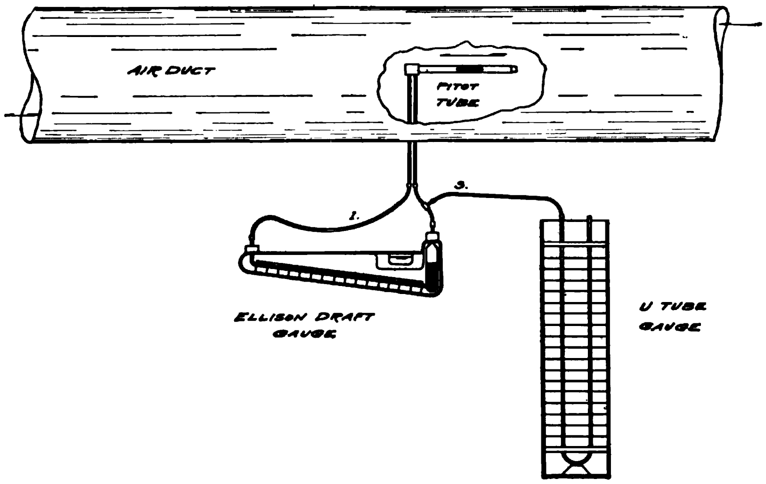

FIG. 50. SHOWING USE OF PITOT TUBE AND DRAFT GAUGES.

this it is readily deduced that an ounce pressure per square inch is produced by a water column 1.75 inches high and that 1 inch head of water is equivalent to 0.578 ounces per square inch. Table No. 16 shows these relations at different heights of water column. Table No. 15 indicates the height of a water column corresponding to any given pressure in ounces per square inch.

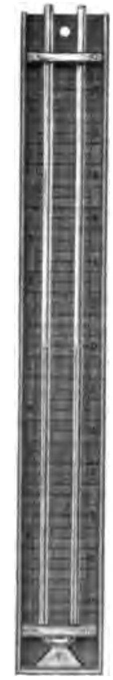

Fig. 51. U Tube Gauge.

137. The Ounce Gauge

For measuring large differences in pressure, the ounce gauge is often employed. A form of ounce gauge, manufactured by this Company and capable of measuring up to 20 ounces pressure, is illustrated in Fig. 52. One arm of the U tube is made of brass tubing and is provided at the top with a cup of such a size that practically constant level is maintained therein under the different conditions of pressure. The scale is constructed with this level as its zero mark. To change the readings of this scale, which are in ounces, to inches of water, Table No. 15 may be used.

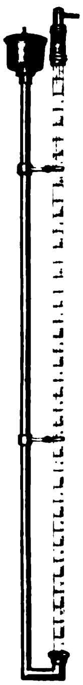

Fig. 52. Ounce Gauge.

138. Differential Draft Gauge

The differential draft gauge is a form of U tube for measuring with accuracy small differences in pressure. In the form most generally used by this Company, it consists of a glass tube made of two vertical arms joined by a long connection from the bottom of one to the bottom of the other and inclined at a slight angle. (See Fig. 53.) Thus, if the inclination of this tube is, say, 1 inch in 10, then the pressure corresponding to 1/10th of an inch, is registered on a scale under the inclined tube by a displacement of 1 inch along the tube. One arm of the gauge is a reservoir in which the fluid is maintained to such a height that the meniscus of the fluid in the other arm comes at the zero mark on the scale. Pressure on this end of the tube will cause the fluid to back up in it, the actual amount in inches of water being read from the scale. Owing to the accuracy required of this instrument, oil and not water is used; the scale, however, is graduated to read inches of water.

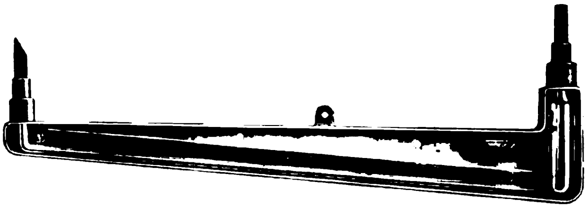

FIG. 53. ELLISON DIFFERENTIAL DRAFT GAUGE.

139. Hook Gauge

For the determination of very small differences of pressure, a device known as the hook gauge is used. This is a form of the U tube, but the level of the water is very accurately ascertained by the aid of a hook gauge. As is evident in Fig. 54, this instrument consists, in effect, of two tubes of relatively large diameter made in one casting. The tubes communicate near the bottom through an opening, so that a constant level of the water within them may be maintained so long as they are both exposed to the same pressure. The hook having been set so that its point is

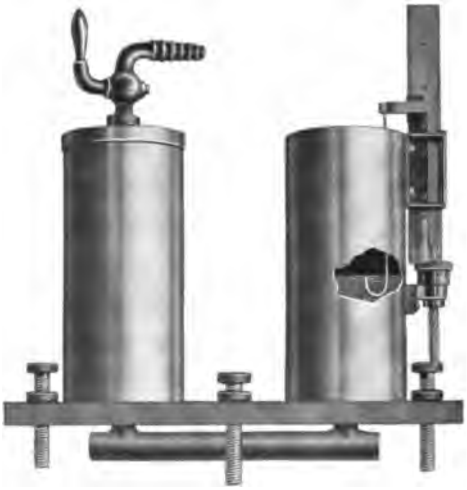

FIG. 54. HOOK DRAFT GAUGE.

just at the surface of the water, and the micrometer reading having been taken, connection may be made to the air cock at the left. The pressure thus exerted through the air cock changes the level of the water within the tube which communicates with the pressure to be observed. The hook is then adjusted to the new level and the difference in pressure measured by the difference in water level. The micrometer screw with its graduated head makes the reading of pressure differences to. .01 of an inch a comparatively simple matter. Evidently, such a gauge gives only relative readings, but it may be so graduated as to indicate the total difference in water levels. The two readings, the difference between which gives the pressure in inches of water, make it unnecessary to bring the water to any stated level under atmosphere pressure.

140. Measurement of Velocity

If a single reading be taken with the Taylor pitot tube and the differential water gauge, the tube being held in the centre of the air duct, this value of the velocity head so determined must be multiplied by the coefficient .828 in order to obtain the average velocity head for the entire section.

The velocity of the air is then determined from the formula:

$$V = 60\sqrt{2gh}$$

in which V = Velocity in feet per minute
g = acceleration due to gravity = 32.16
h = head of air in feet

To change h into head in inches of water = h'', the following formula is used:

$$h = \frac{h'' \times 62.5}{12d''}$$

in which d'' is density of air at temperature and pressure of existing conditions and 62.5 is density of water.

The expression is therefore:

$$v = 60\sqrt{2g\left(\frac{5.2h''}{d''}\right).828}$$

which with air at standard density of .075 reduces to

$$v = 4000\sqrt{h''}$$

141. Tests

It is often found necessary to test a system to determine if it is working properly or if the proper amount of air is delivered to the various rooms. A method of testing must therefore be decided upon and it is necessary to know the instruments and methods used to make the test. The following paragraphs give, in a general way, a description of the principal instruments and methods most usually employed in making tests of heating and ventilating systems.

In making tests, it is first necessary to see that the system is open, that the registers and vents and all dampers are open. The speed of the fan is made to correspond with that desired, and the steam pressure in the heaters is measured. By placing thermometers in every room the temperature may be observed. Thermometers should be placed on the inside walls of the room near the vent registers. If on account of severe exposure or improperly proportioned ducts certain rooms are hotter or colder than the temperature desired, the deflection dampers in the ducts are adjusted until the proper conditions are obtained.

In order to obtain the volume of air flowing through the various registers, the anemometer is used and the frequency of air change is determined by dividing the contents of the room by the volume of air entering through the registers. The anemometer is described in Section 132. A check upon anemometer readings can be obtained at times by the pitot tube if there is a length of pipe long enough to use the pitot tube with accuracy.

The resistance of the piping system is checked at the fan outlet by means of the pitot tube and the resistance of the suction in the same manner. If these are higher than was originally calculated, the fan may be operated at higher speed to give the desired volume against this increased pressure.

142. Thermometers

Good mercurial thermometers, of the usual construction, are generally sufficiently accurate for observing the ordinary temperature of air, but for noting the temperature of the steam, or of highly heated air, the form shown in Fig. 55 is very convenient. The thermometer tube is inclosed in a tubular brass case, the lower end of which is provided with a screw of standard size and thread, by means of which it may be securely inserted in any T or flange. The tube projects well down below the threaded portion, and is guarded by a small pipe attached to the bottom of the case, which allows free circulation around the bulb of the thermometer. The glass may be graduated to read between any given temperatures. For instance, if the thermometer is to be employed exclusively for ascertaining the ordinary temperature of steam, its range need not be greater than between the points 200 degrees and 350 degrees.

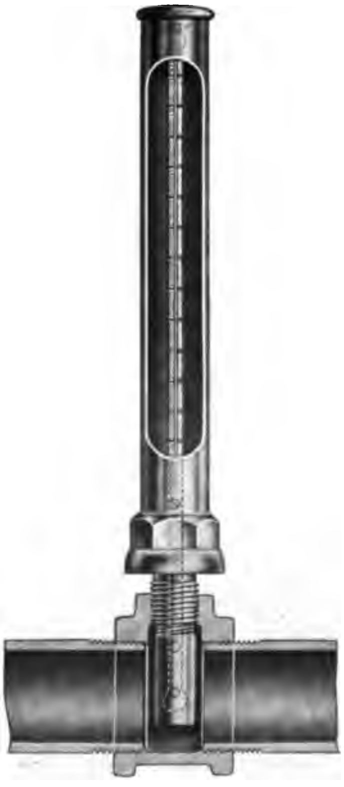

FIG. 55. THERMOMETER.

143. Determination of CO_2

The amount of carbon dioxide present in the atmosphere may be readily ascertained to a sufficiently close degree of accuracy for practical purposes in the following manner: Six clean, dry and well-stoppered bottles, containing respectively 100, 200, 250, 300, 350 and 400 cubic centimeters, a glass tube containing exactly 15 cubic centimeters to a given mark, and a bottle of perfectly clear, fresh limewater, constitute the apparatus required. The bottle should be filled by means of a hand-ball syringe with the atmosphere to be examined. Add to the smallest bottle 15 cubic centimeters of the limewater, put in the cork and shake well. If turbidity appears, the amount of carbon dioxide will be at least 16 parts in 10,000. If no turbidity appears, treat the bottle of 200 cubic centimeters in the same manner. Turbidity in this would indicate 12 parts in 10,000. In similar manner, turbidity in the 250 cubic centimeters bottle indicates at least 10 parts in 10,000; in the 300, 8 parts; in the 350, 7 parts; in the 400 less than 6 parts. The ability to conduct more accurate analyses can be attained only by special study and a knowledge of chemical properties and methods of investigation.

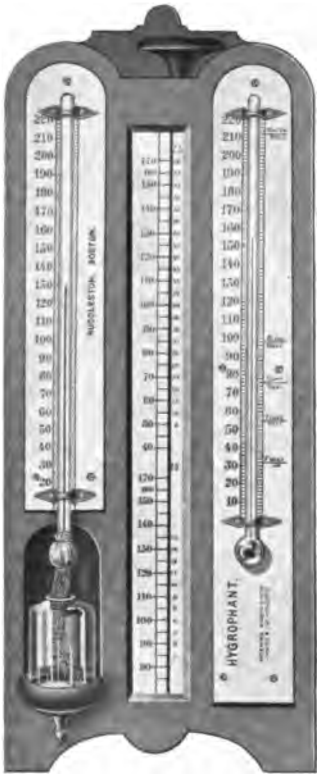

FIG. 56. HYGROMETER.

144. Measurement of Humidity

In many ventilating systems it is necessary to know the humidity of the air. Of the numerous instruments in use today for ascertaining this, the most common and the simplest is the wet and dry bulb hygrometer. Fig. 56 shows one of these.

The instrument consists of two thermometers mounted together upon the same backing but separated so that one cannot influence the other. The bulb of one of these thermometers is covered with a muslin cloth which is kept moist by immersion in a small flask of water. The evaporation of moisture from this muslin cools the thermometer bulb so that the temperature registered by this thermometer is lower than that registered by the dry bulb thermometer. As the rate of evaporation from the wet bulb is dependent upon the relative humidity of the surrounding atmosphere, the degree of refrigeration obtained thereby bears a definite relation to the relative humidity. Thus, to determine the relative humidity by means of the wet and dry bulb thermometers, the temperature as registered by both thermometers is noted and by comparison with tables and charts, the values of the relative and actual humidities can be obtained. (See Table No. 21.)

Wet and dry bulb thermometers are not satisfactory means of measuring humidity, unless they are placed in a moving draft of air. For this reason, an instrument known as the sling psychrometer is used for taking measurements in still air of which the humidity is to be ascertained. As the illustration of Fig. 57 indicates, a wet and a dry bulb thermometer are mounted together on a backing which is provided with a pivoted handle so that the instrument may be rapidly revolved in the air. The temperatures are then observed and the calculations made as before.

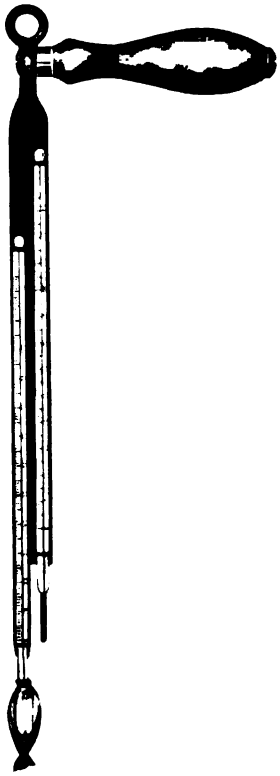

FIG. 57. SLING PSYCHROMETER.

CHAPTER VIII

SPECIAL PROBLEMS OF APPLICATION

145. The Application of the Sturtevant System

WHEN the requirements of good ventilation and heating are understood, the best method of meeting these requirements in various types of buildings presents itself. So many factors enter into the consideration of individual problems that, while the principles of heating and ventilation may be clearly understood, the methods of applying them are not so easily obvious.

It can be well understood that different types of buildings require entirely different treatment, and that every building presents its own individual problems, the peculiar features of which make necessary a most careful consideration of all the factors entering into the heating and ventilating problem. There are certain general characteristics which are found in every building of a certain type. It is the purpose of the following pages not to lay down rules by which heating and ventilating systems must be calculated, but to bring to the attention of the reader the most prominent problems peculiar to various types of buildings to which the Sturtevant System of heating and ventilating is applicable.

146. Single Story Buildings

Simplest of all buildings requiring ventilation are those shops, mills, exhibition halls and factories which have but one floor. They have, however, generally one room with walls and roof exposed and offering a considerable amount of radiating surface through which a loss of heat takes place. The heating apparatus

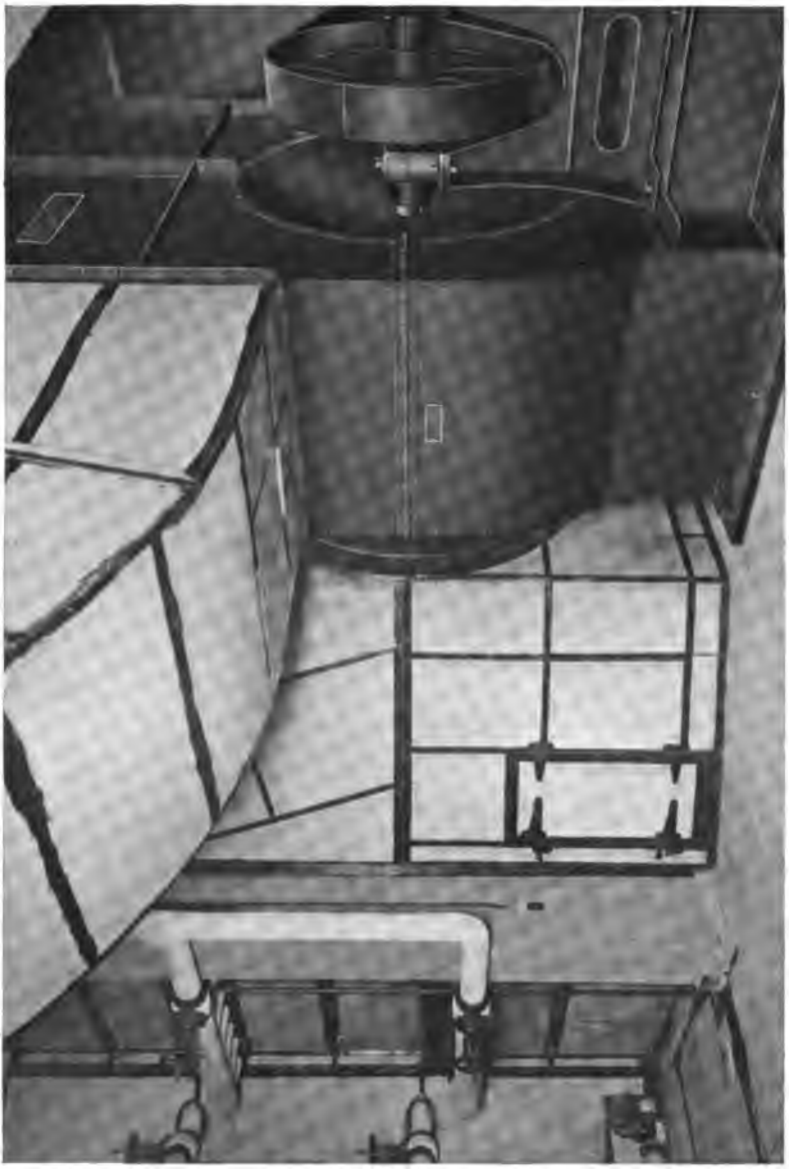

Fig. 58. One of the Thirty-six Sturtevant Multivane Fans in the Pennsylvania Terminal, New York City.

must, therefore, be large enough to allow for excessive heat loss from the buildings and the distributing ducts must be carefully placed so that the building is most economically heated and the heat supplied to the right place, for underheating at the floor and overheating at the ceiling is one of the most natural consequences of an imperfect system of distribution. Under such circumstances the apparatus is frequently condemned as having insufficient capacity, when the trouble lies entirely in the manner in which the heated air is delivered to the building.

147. Rapidity of Warming

One of the greatest difficulties in a building of this character is to heat it rapidly in the morning after it has cooled during the night. No other system can meet this requirement so completely and rapidly as the blower system in which hot air is forced to every corner of the building. When it is desirable, the engine may be run slowly all night and the building maintained at a moderate temperature. If the exhaust from the engine is used in the heater, the expense for motive power is eliminated. The ability to recirculate the air facilitates very materially the rapidity with which the building may be heated.

148. A Typical Shop Apparatus

A typical installation of Sturtevant heating apparatus is shown in Fig. 59. Two apparatus make up this installation, each with heater, fan and engine. It will be noticed that these heaters are arranged for using the air of the shop, it being drawn in through the pipe coils, exposed on the ends of the heaters. No arrangement of dampers permitting the use of either outside or inside air was considered necessary, as the shop is very large, is occupied by but relatively few workmen, and there are no other agencies vitiating the atmosphere. The doors of this shop are open so frequently that the air is changed several times in the course of an hour.

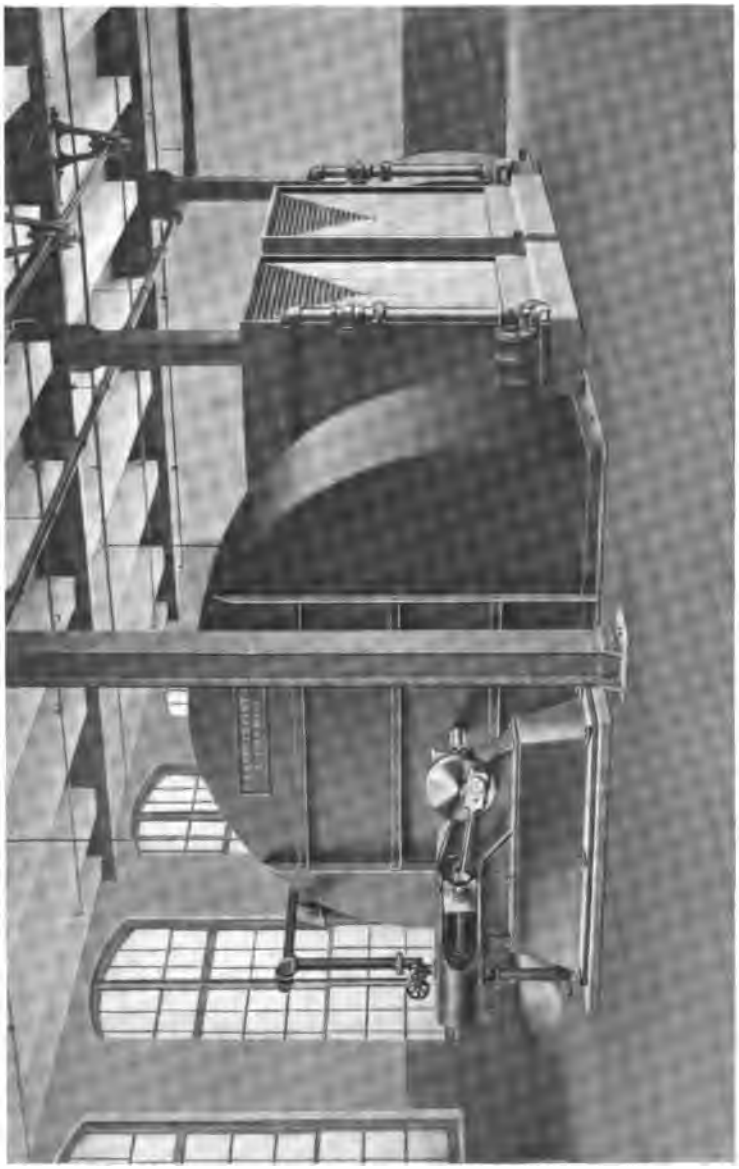

FIG. 59. TWO STURTEVANT HEATING APPARATUS FOR FACTORY HEATING.

149. Recirculation of Air

In manufacturing buildings, heating is generally of more importance than ventilation, since the number of persons vitiating the air is relatively small compared with the volume of air within the building. Some ventilation is, of course, necessary and one of the advantages of the Sturtevant System lies in the fact that it insures sufficient supply of air for ventilation. Since the air supplied through the heating system is generally in excess of that required for ventilation, considerable economy may be effected by a recirculation of the air from the shop. An arrangement of doors or dampers connecting the heater with the shop or outside air permits the fan to draw shop air or outside air, as is desired. When recirculated, the air of the shop does not become as vitiated as might be imagined, as there is sufficient leakage of air into the shop through open doors and loosely fitted windows to maintain the ventilation at the desired standard. There are, in fact, numerous shops where working conditions are the best that depend entirely upon this method for replenishing the supply of air, having no provision for drawing air directly from the outside. On the other hand, conditions should be investigated to discover if there are any agencies causing the vitiation of air other than that by the occupants of the building. Owing to the nature of the manufacturing processes carried on in some buildings, it is impossible to recirculate the air without dangerous results. In these buildings, where dust, gases, fumes and smoke pollute the atmosphere, the Sturtevant System is most valuable because of the ventilation it furnishes.

150. Buildings of More than One Story

An increase in the number of stories increases the complications in the manner of heating a building. The simplest arrangement that, in many cases, can be made in the multi-story building is the scheme that prevailed in the one storied building duplicated upon each floor.

In a building of more than one story, however, the flat ceilings and the relatively small distances from floor to floor as compared with the height from floor to roof in single story buildings make the matter of distribution of air to a given floor very much easier. With smooth ceilings, unobstructed by beams, shafting or belting, air discharged horizontally at high velocity just beneath the ceilings may be forced for long distances, as to the opposite side or end of the room, before its volume becomes seriously dissipated. Of course, this movement reduces to just this extent the necessity of distributing pipes.

Where beams exist, extending below the ceiling and interrupting the air movement, the currents are quickly broken up and it is impossible to compel the air to move a great distance beyond the outlet. The influence of shafting with its moving belts and pulleys is very noticeable in a manufactory, particularly a textile mill. Under such conditions, if the air supply openings are sufficiently numerous, this moving machinery plays a most beneficial part in thoroughly mixing the incoming air with that in the room.

There are two principal methods of arranging ducts and flues for the distributing system in a building of more than one story and of a size exceeding 50 by 100 feet in floor plan.

First, the introduction on each floor of a complete system of overhead piping, lengthwise of the building, with outlets at intervals, the pipe on the various floors being fed by a stand-pipe at some convenient point. Second, distribution from a number of vertical flues placed at intervals down the centre or along the sides of the building, every flue discharging to every floor and all being supplied by a main duct in the basement or lower floor. In its ideal form, this is the arrangement adopted in textile and similar mills where the flues are built of brick on the outside of the building and along one side. Such a system should be decided upon before the erection of the building is begun, in order that the placing of flues in the mill may be accomplished with architectural harmony.

In fact, although too seldom the case, it is very desirable that the location and arrangement of even a galvanized steel distributing system should be determined before work has progressed too far. Inattention to this matter frequently causes great inconvenience in the introduction of the system which, when appreciated, cannot be overcome readily.

151. Paint Shops

Large paint shops, such as those in which railway coaches and cars are painted and varnished, are advantageously heated by the Sturtevant System. The abundant supply of warm, dry air furnished by the fans facilitates the process of drying very materially. Care should be taken in designing a system for a paint shop to avoid high velocities at the outlet of the hot air ducts in order to prevent dust from being stirred up or blown on to the fresh paint. Outlets should be placed so as not to discharge directly on the painted surfaces.

The photograph reproduced in Fig. 60 gives a clear conception of the application of the Sturtevant System to a paint shop. The heater and fan are housed in a special room half-way of the building's length. A duct of concrete, built underground, leads across the centre of the building, and from this four branch ducts of tile extend to the ends of the building on each side. Galvanized steel risers, shown in the photograph, are fitted into Y branches in these distributing ducts and through them the air is finally discharged into the room. Each outlet is fitted with a hand-operated volume damper of the butterfly type so that the discharge from it may be independently controlled.

152. Planing Mills

In figuring heating apparatus for a planing mill, account should be taken of the air exhausted from the mill by the planing mill exhausters and the heating fans should be sufficiently large

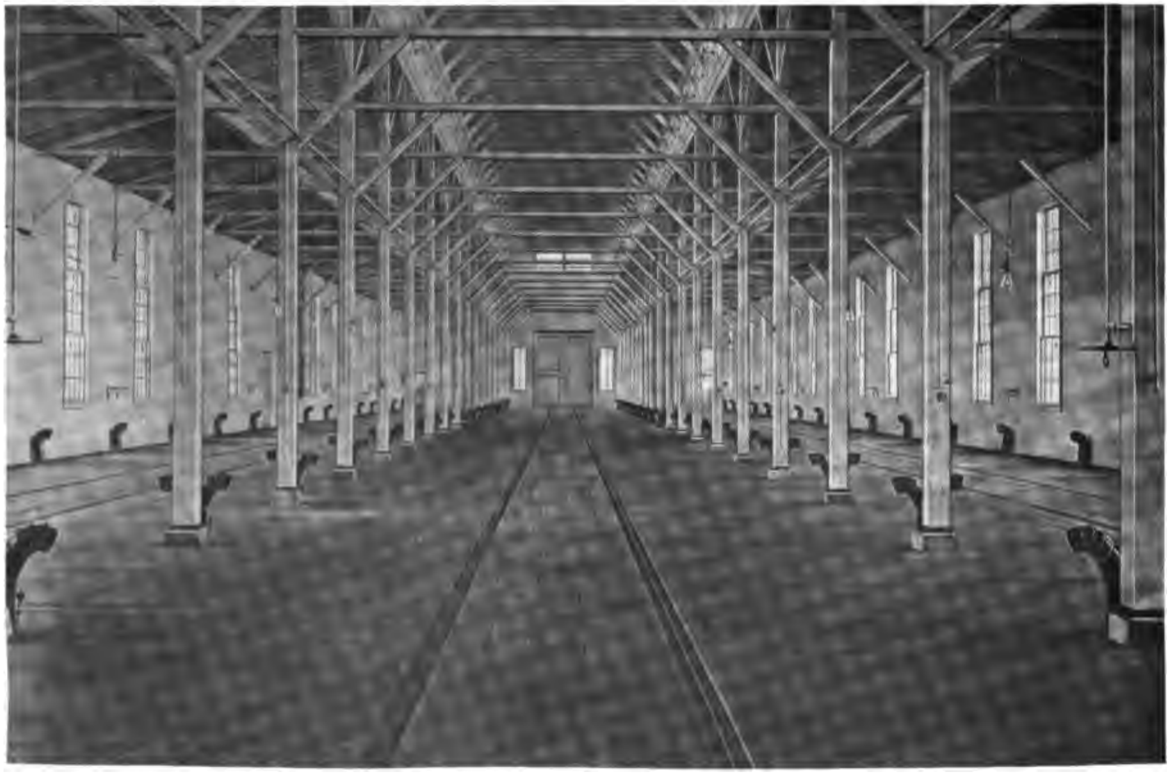

Fig. 60. Interior of Paint Shop, N. Y., O. and W. R. R., Middletown, N. Y. Showing Warm Air Outlets.

to supply air in excess of that exhausted. Otherwise, the slight vacuum created within the mill by the exhausters would permit the inleakage of air through cracks in windows and doors, and it would be found difficult to heat the mill sufficiently in severe weather.

153. Glass Walled Buildings

A type of building construction that is finding much favor lately because of the abundance of light that is admitted, is the modern glass and steel construction. Many buildings for manufacturing purposes are built with windows comprising almost the entire wall of the building; mere skeletons of steel, concrete or brick with walls of glass. The high rate of transmission of heat through glass necessitates a larger apparatus for heating this type of building than the ordinary building would demand. The recirculation of air through the heaters and fans is a means of economy that may be utilized in such buildings to offset the losses due to excessive radiation.

154. " Saw-tooth " Roofs

Where there is a large floor area with many machines grouped closely together, as in a machine shop or mill, the saw-tooth roof is often used as a means of admitting light. This form of construction permits the light to enter through the roof while it excludes the direct rays of the sun. The extreme exposure of such a construction is at once evident. In area, the saw-tooth roof is considerably greater than the flat roof, while the large amount of glass permits the rapid loss of heat. The roof itself is more exposed to the winds as well. Moreover, as these roofs are often low and as the shop or mill generally contains many operatives, ventilation is necessary.

All these facts should be carefully considered in designing a system for such a mill or factory. Where the roofs are low and where there is considerable shafting and belting in the mill or

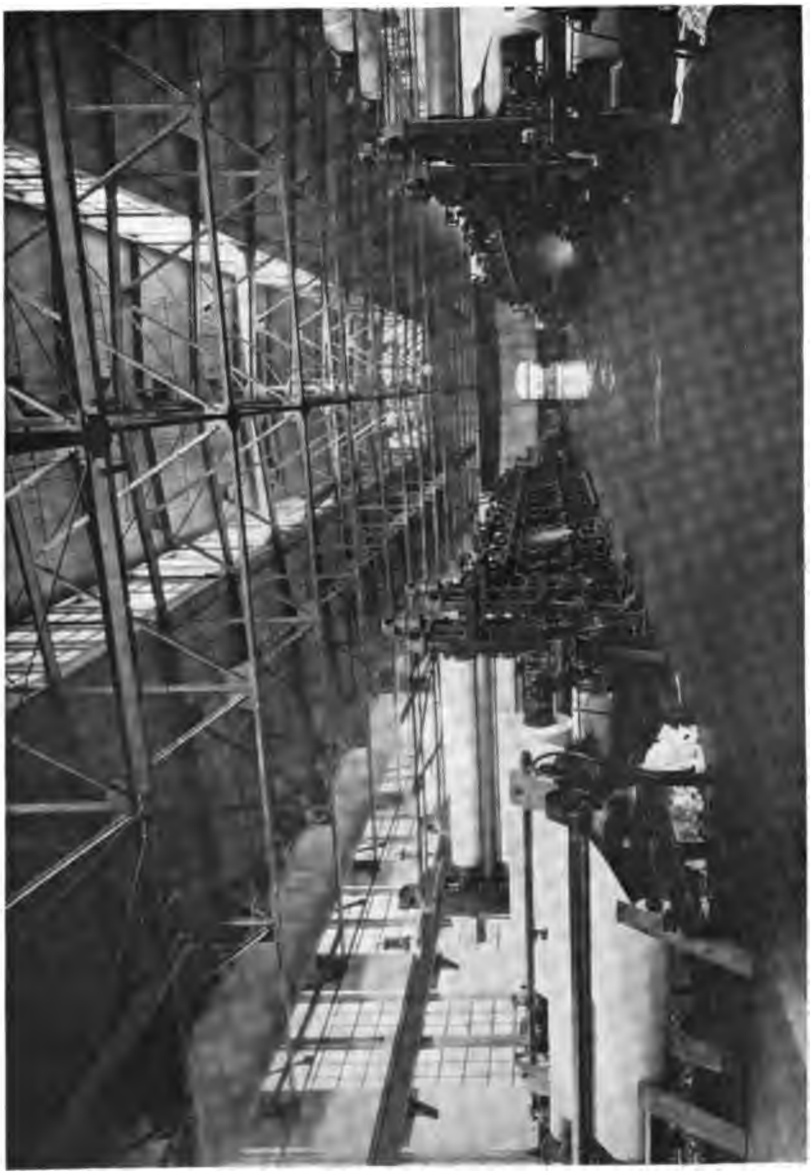

Fig. 61. Ventilating Arrangement in Paper Mill.

factory, the stand-pipe method of distribution is often used. This is described in Section 118, Chapter VI. Briefly, the fan and heater are placed below the floor, the fan discharging into a vertical stand-pipe of galvanized steel topped with short discharge pipes radiating horizontally in all directions. Another method of distribution is to run galvanized steel pipe under the gable of the saw-tooth roof and crosswise of the building. Installed in this manner the pipes do not interfere with shafting or belting. Short discharge pipes are placed in these main supply ducts and through these the warm air is blown into the building. Roof ventilators are often provided to allow the vitiated air to escape.

155. Paper Mills

The abundant supply of air that is insured by the Sturtevant System is of special value in paper mills. In buildings of this character, as well as others, such as dye-houses and places where considerable steam or moisture is in the air, the large volumes of air absorb the moisture and remove it from the room.

For every pound of paper manufactured, there are about two pounds of water evaporated, and provision must naturally be made for the removal of this. Air is therefore usually supplied in abundant quantities. Hoods, connected to exhaust fans, should be used over individual machines to remove steam and prevent it from condensing on the walls and ceilings of the building.

156. Textile Mills

The peculiar conditions found in textile mills require a heating and ventilating apparatus that will give plenty of fresh, clean air at proper humidity and temperature. The character of textile products is so seriously affected by the atmospheric conditions prevailing in the mill that it is necessary to regulate the ventilation and heating to a very close degree. This necessitates dependence upon mechanical ventilation because the windows generally are closed. Moreover, the number of operatives per cubic foot of content is relatively high so that vitiation of the air of the mills is rapid. The heat generated by their bodies as well as that by the moving machinery is a large amount, and it is necessary to provide ventilation rather than heating for this reason.

The air washer is an important and necessary adjunct to the heating and ventilating equipment of the modern mill as by means of it the air may be properly cleaned of its impurities, insuring a clean mill and superior product and the humidity of the air may be regulated to the necessary degree.

157. Electricity in Textile Mills

The presence of frictional electricity, generated by the motion of belts, pulleys, running stock and machinery, is a source not only of annoyance but of positive loss to mill owners. In carding and spinning particularly, electricity has the effect of causing a change of several numbers in the yarn, and as much as 3 per cent. in the weight, weakening the yarn and causing it to snap and break; while the quality and width of woven goods is noticeably affected. The effect which moisture in the air has upon electrification in the rooms appears to be dependent upon the relative humidity in the mill rooms. If there is sufficient moisture in the atmosphere, there is no trouble; if there is not sufficient moisture, electricity always appears.

As moisture depends upon the currents of air to distribute it, no better means can be found than the Sturtevant System for obtaining the required results. While doing efficiently its duty as a heating and ventilating medium, the air may be moistened and the exact humidity of the air regulated to the closest degree. With an average temperature of 70 to 80 degrees in the room, the relative humidity need not exceed 70 per cent. This will insure a comfortable atmosphere, and will prevent absolutely the presence of any electricity. The mere benefit from this particular source will repay any enterprising owner the expense of installation, in these days when a fraction of a cent per yard is of vital importance. But with the additional advantage of an efficient heating and ventilating apparatus, controllable under all conditions, there can be no hesitation as to the desirability of the system.

158. Loft Buildings

The problem of heating the loft building is much the same as that of heating a large, many storied mill. Owing to the number of tenants, the fact that their desires for heating and ventilating cannot be anticipated and that part of the building may from time to time be vacant, a desirable arrangement may be had in the installation of a separate and independent system on each floor. The landlord thus protects himself by providing apparatus for heating and ventilation, yet does not lay himself open to criticism for the way in which he regulates the supply of heat, as the operation of the system is in the hands of the tenant himself, and moreover, in the case of untenanted floors, he does not have the expense of operating a large system when a smaller one is all that is necessary. The responsibility of the operation of the system is in the hands of the tenant himself, and the desires or needs of one do not affect the comfort or convenience of another.

While the original outlay for the installation may appear excessive, results in economy of operation more than warrant the added investment. A single heater, with proper distributing system for the air, can be applied to these buildings, if desired.

159. Foundries

The introduction of the Sturtevant System for the heating of foundries insures not only the proper temperature within the building, but ventilation as well, and in the summer, by disconnecting the heaters, the fans may be used for cooling and ventilation. A distributing system of galvanized steel ducts is generally used in foundries. These ducts discharge either directly or indirectly by means of short flues into the foundry at a distance of from 8 to 15 feet above the floor. Individual dampers are often supplied at the outlets of the heating duct so that the discharge of air may be regulated as is desired. Disc or propeller fans, placed in the upper walls of the foundry, will remove the smoke and aid very materially in maintaining a comfortable temperature and a clear atmosphere.

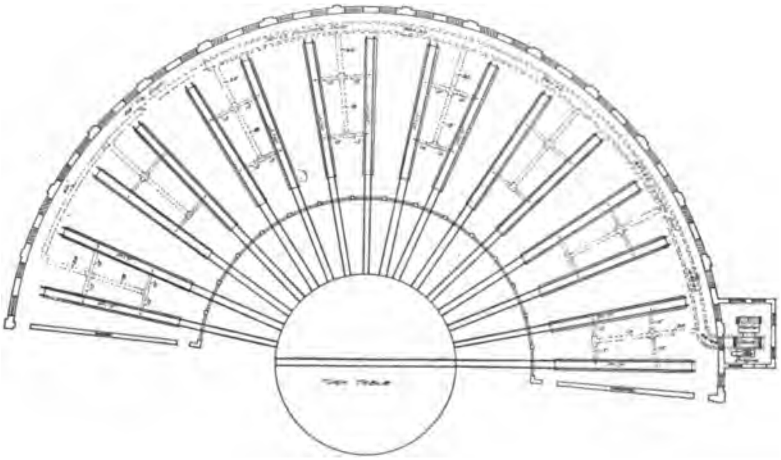

FIG. 62. TYPICAL ROUNDHOUSE ARRANGEMENT.

160. Locomotive Roundhouse

Certain conditions, peculiar to locomotive roundhouses, make the Sturtevant System most advisable for heating. At all times of the year an effective means of ventilation and of removing the steam and smoke emitted by the locomotives is essential. The Sturtevant System is, in the winter, most particularly valuable as a means not only of supplying necessary warmth for the workmen but for melting the ice and snow accumulating on the running gear of locomotives as well, of removing the resulting moisture and of softening the congealed lubricating oil.

The usual method of arranging a distributing system is plainly indicated by Fig. 62, which shows a Sturtevant System as installed in a roundhouse. Fan, heater and engine are located in a house built as an addition to the main building. Heated air is distributed by means of an underground concrete and tile duct which follows the contour of the building, and, from which, branch ducts lead radially inward between the engine pits, discharging directly into them. Warm air is thus admitted directly under the locomotives whence it rises, melting the ice and snow that may be on the running gear. Escaping by ventilators provided in the roof, steam, moisture and smoke are carried away from the building while the atmosphere within is comfortably warm and free from smoke and dampness.

Testimony of those intimately acquainted with the actual working of the Sturtevant System shows that comfortable temperatures are easily maintained in the severest weather, that the actual saving in fuel is more than sufficient to warrant the original expense, and that locomotives can be sent from the roundhouse as well cleaned and oiled in winter as in summer.

161. School Buildings

There is no class of buildings with which a question of ventilation and heating is as important as with school buildings, for it is here that children are gathered for hours at a time throughout the most important years of their growth. The dangers from poor ventilation are more serious in school buildings than in factories, stores, or offices on account of the close seating of the occupants, and the long periods through which they are confined. It is practically impossible to secure satisfactory ventilation through open windows, even as an aid to mechanical ventilation, as weather conditions seriously affect ventilation by this means.

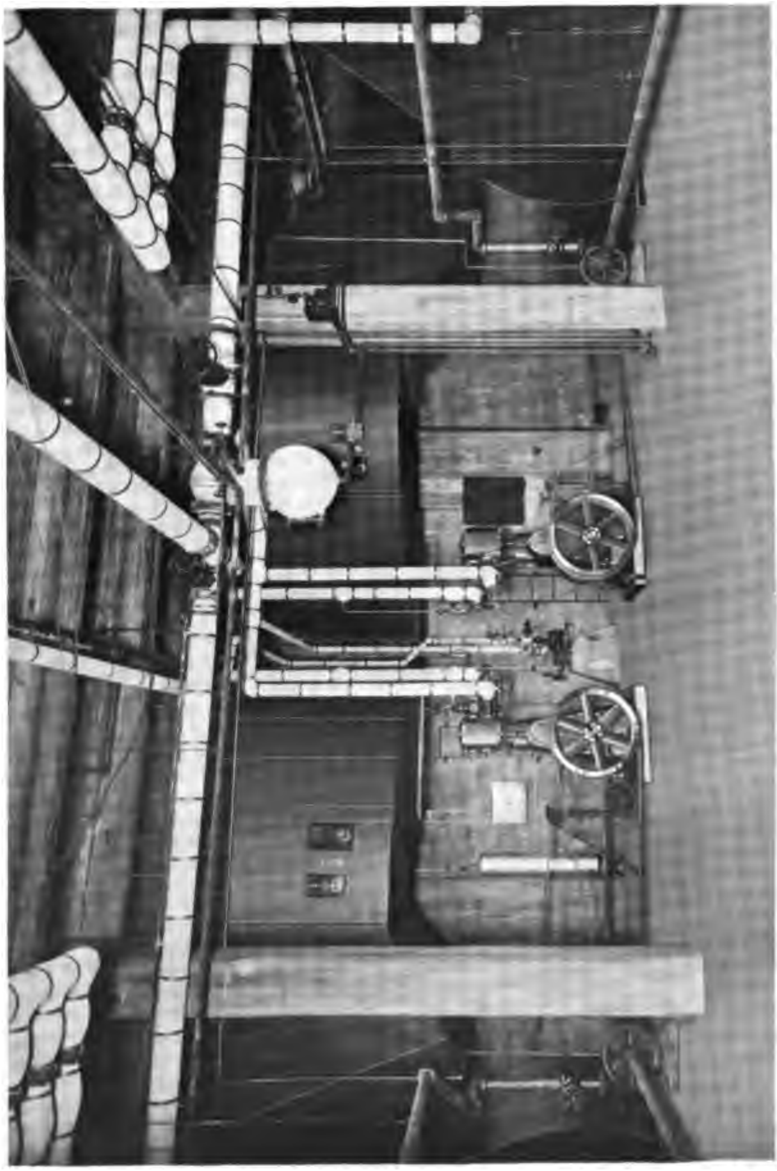

FIG. 63. VENTILATING APPARATUS, UNIVERSITY OF CINCINNATI, CINCINNATI, O.

The harm that might result from an exposure to bad atmosphere once or twice a week as is the case in churches, theatres and places of amusement is very slight compared with the persistent effects from vitiated atmosphere in the continuously occupied school room. Open air schools have proved conclusively the value of fresh air in school rooms. With the Sturtevant System, the fresh air supplied to school buildings is warmed to the proper temperature, with the humidity closely regulated if so desired, and with the dust and impurities of the air washed from it.

162. Amount of Air Necessary

It is generally considered necessary to supply at least 30 cubic feet of air per minute, per pupil, and this amount is required by most laws regulating ventilation of school buildings. In the ordinary school house, there is a space allowance of from 160 to 250 cubic feet per scholar. With even an insured volume of 250 cubic feet, and with a supply of 30 cubic feet per minute, per pupil, it is necessary to change the air at least once in 8 minutes. Supplying and removing such large amounts of air in so short a space of time make it necessary to supply large ducts, flues and register openings so that the velocity of air entering and leaving the room is low enough to guard against noise in the register and drafts through the room.

163. Location of Apparatus

In locating apparatus in the basement of the school building, it is well to choose a central position in order to economize distributing pipes and to choose one under a corridor so that any possible noise may be avoided in the school room. It should be possible to regulate the temperature of the air entering the individual rooms and if a double duct system is not used, heating coils should be placed in the bases of the flues or in the rooms themselves. With such arrangements, a room which is exposed

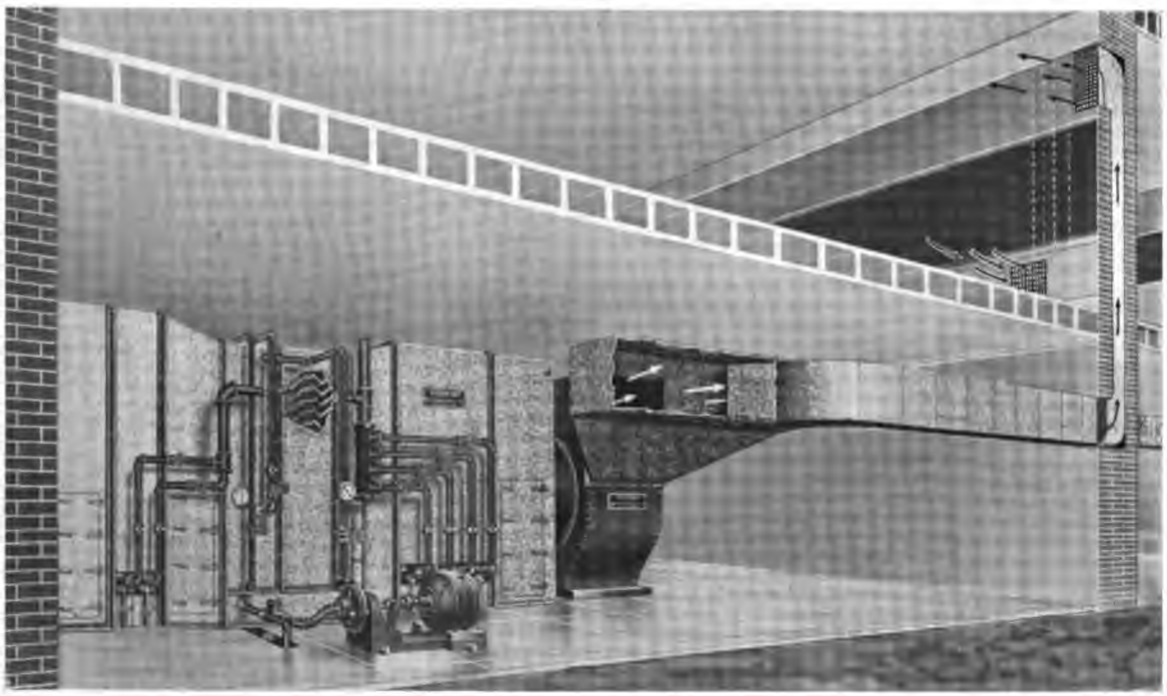

FIG. 64. SCHOOL BUILDING SECTION SHOWING AIR ENTERING AND LEAVING.

to the most severe conditions of the weather may be maintained at the proper temperature without keeping the other rooms too warm.

The distributing ducts in the school buildings are usually made of galvanized steel when the basement construction is of such a nature as to permit its use. Underground concrete or brick ducts are sometimes used. When galvanized steel piping is used, flat rectangular ducts suspended from the ceiling economize both material and room.

The plenum system is almost universally used in school buildings without the aid of an exhaust fan, although the latter may be used if complexity of the building demands it, or if it is necessary to exhaust from kitchens, toilets or laboratories.

164. Locating Flues

School houses are designed so that every room has a maximum outside exposure and modern school buildings are supplied with especially large windows. In figuring heating and ventilating apparatus, attention should be placed upon these features of construction. Most school houses have interior walls of brick, which provide ideal positions for vent and heat flues. Air from the heater fan is discharged into the room through a register in an inside wall near the ceiling and is directed across to the opposite side of the room where it is cooled by the relatively colder surface of the outside wall and where it sinks to the lower part of the room. Vent flues in the same interior wall as the inlet registers remove the vitiated air through registers set in the wall just above the floor.

165. Churches

The usual construction of a church presents a floor that is practically level and compels the introduction of air vertically through it, or else its supply from the side walls. To secure the best distribution the latter arrangement is usually adopted, rendering the manner of heating the ordinary church but little different from that of a hall of audience.

The intermittent use of a church, however, introduces one of the most important problems in the design and introduction of a heating and ventilating system. As a rule, upon Sunday, practically all the rooms in the building are in use, sometimes the auditorium and Sunday School rooms coincidently, sometimes consecutively, while less frequently one is occupied in the morning and the other in the afternoon. Furthermore, the parlors, pastor's study, or small lecture rooms, may be required to be warmed only on certain days of the week.

Evidently, then, the system installed must be varied in its adaptability and rapid in its ability to warm up the building after it has been thoroughly cooled down. For occasional warming of small rooms where ventilation is not an all-essential feature, direct radiation will be found most advantageous, while provision may be made for supplying air to the same apartments when the blower apparatus is in operation.

A great advantage with the Sturtevant System is found in the ability to cool the church during the warm weather. The same fan which in the winter is used for forcing warm air into the church can be used in summer for circulating cool air. The temperature within the church can thus be maintained within the limits of comfort throughout the entire year. Ventilation is also always obtainable.

166. Hospitals and Asylums

The evidences of insufficient ventilation are nowhere more pronounced than in buildings devoted to the use of the sick and diseased. Constitutions already weakened are very quickly rendered still more susceptible to the further inroads of disease by exposure to a vitiated atmosphere. The marked improvement in the healthfulness of such buildings where good ventilation obtains was pertinently shown in Section 18, Chapter II.

Because of the more perceptible benefits of pure air in buildings of this character, they have long been the subject of thoughtful study as to the best means to secure the desired ends. Long before efficient systems of ventilation were applied to other buildings, the hospitals of this country and of Europe were equipped with ventilating devices that in their day were far in advance of those introduced in any other structures.

In no buildings should the ventilation be more carefully considered in the development of the original plans than in those of the class under consideration. The intended use of each room must be known, the arrangement of beds in the wards should be determined, and even the character of the diseases which are to be treated in the various wards should by no means be overlooked.

In the thoroughly equipped hospital of the present day, there is always special and separate provision for contagious diseases, almost universally in independent buildings. Evidently the maximum ventilation is required under such conditions. The 30 cubic feet per person, deemed sufficient in the school and the hall of audience, becomes utterly inadequate when the atmosphere is laden with contagious disease germs. From a theoretical standpoint, too much air cannot be supplied under these conditions; in practice, however, it frequently runs up to 100 cubic feet per minute per person and over.

To secure the positive supply of such an amount naturally demands positive and mechanical means. In the hospital of moderate size, the plenum system will meet all requirements, but under certain circumstances, in more complicated structures, it becomes desirable to assist its action by exhaust fans.

In the majority of cases, the occupants of asylums are supposed to be in a reasonably healthy condition, so far as the general functions of the body are concerned. The air supply per capita, therefore, usually need be merely that provided for other classes of buildings devoted to similar uses, where the occupants gather in certain rooms or out-of-doors during the day

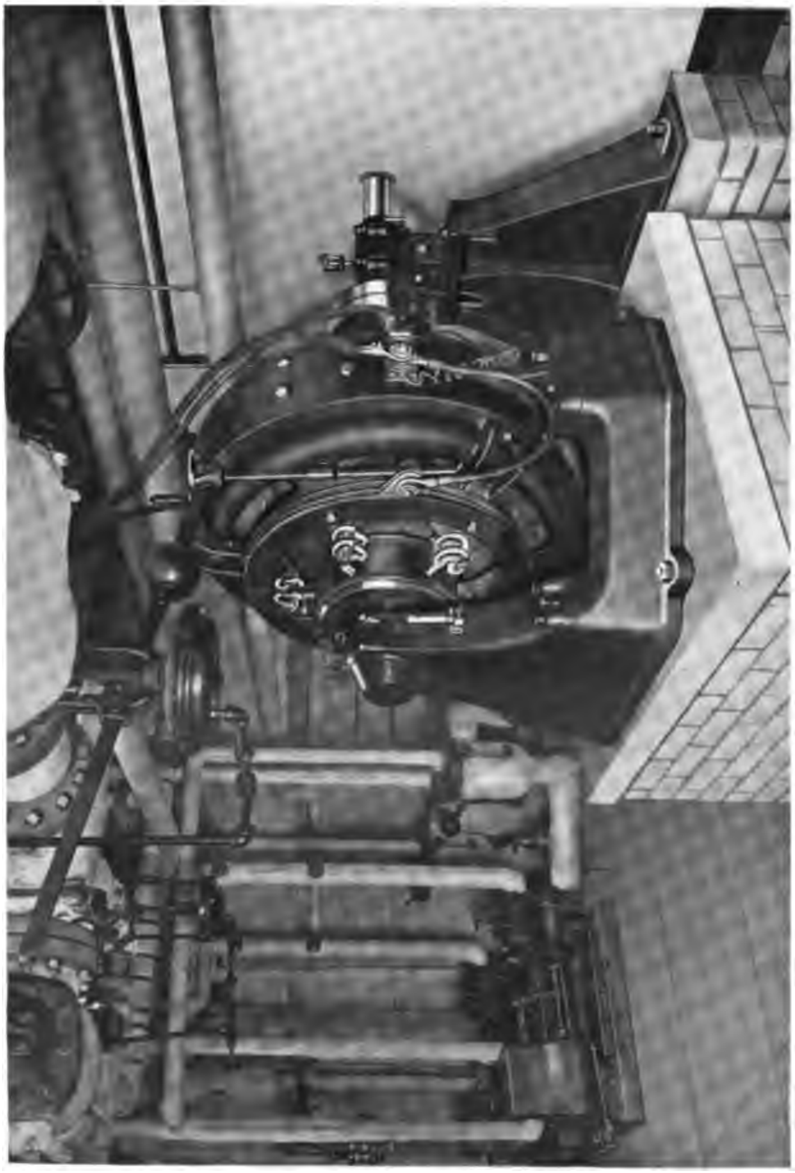

FIG. 65. STURTEVANT HEATING AND VENTILATING APPARATUS, BELLEVUE HOSPITAL.

and return to their dormitories or individual sleeping rooms for the night. Where the violently insane are confined in individual cells the same methods apply as in a prison.

167. Legislative Halls

Because of the character of work carried on within them and their long occupancy, legislative halls may be likened to schoolrooms. An abundant supply of fresh pure air and the rapid removal of vitiated air is essential. Legislative halls are equipped with individual desks and quite generally have a sloping floor which makes it possible to introduce fresh air into the room from below and through individual outlets in practically the same manner as a theatre is ventilated.

168. Court-houses

The conditions which an engineer or architect encounters in designing a system of heating and ventilating for a court-house require his most careful attention. Court-rooms are liable to be occupied continuously throughout the day and often far into the night by many people. Under these conditions, a most abundant supply of air and a perfect ventilating system should be provided for. It is obviously essential that the vitiated air should be effectively removed from the court-room, since the continuous mental strain under which the judge and jury are placed makes it necessary that the atmosphere should be as pure as possible.

A court-house is generally composed of various large and small rooms, all of which may be efficiently heated and ventilated by the Sturtevant System. Ducts and flues are easily carried in the walls and can be artfully concealed as architectural features of the building.

169. Libraries

The Sturtevant System of heating and ventilation is especially adaptable to libraries, as such buildings require a system in which the atmosphere and humidity of the air can be controlled. The heating of stack rooms must be carefully considered as books are injured by excessive heat. Too damp an atmosphere will allow the books to mould, while too dry an atmosphere is harmful to the bindings. Plenty of ventilation is therefore desirable for the welfare of books that are stored in library stacks.

The reading rooms of a library should, above all, have plenty of air for ventilation, because, as a rule, they are occupied continuously for a period of twelve hours and by people who may be afflicted with various diseases of the throat and lungs.

170. Museums and Art Galleries

Equable conditions of temperature and humidity are essential in museums and art galleries because the nature of the exhibits contained therein demands a temperature that varies little from normal and a humidity that is neither too high nor too low. The Sturtevant System is independent of weather conditions, it being possible to control the supply of air so that the temperature and humidity within the heated apartment are constant.

171. Theatres

Great care and experience must be utilized in designing a system of heating and ventilation for theatre buildings. Because of the construction of these buildings, there are peculiar conditions which must be understood perfectly in order that the installation may be successful. The ordinary theatre consists of three parts: first, the body of the house, or auditorium; second, the stage and dressing-rooms; and third, the foyers, lobbies, corridors, stairways and offices. Although these parts are distinctly separate, they are at times thrown together as the rise of the curtain makes the auditorium and the stage one room, while the opening of doors into the corridors permits the interchange of heat and air between these sections of the theatre. It can be readily seen that arrangements based entirely upon the constant separation of these various apartments may be seriously interfered with, if it is possible to change so suddenly and so radically these conditions. As most theatres are built with buildings abutting on two sides, the only means of entrance for air is from the front or the rear, so that ventilation from windows is practically an impossibility. The Sturtevant System is especially adapted to supplying ventilation for theatres, because the air is forced to flow through ducts and flues into the building, while the foul air is forcibly exhausted from it and discharged out-of-doors. Independence of atmospheric and weather conditions makes it possible to secure perfect ventilation throughout the theatre at all times.

In order to guard against drafts from outside, it is generally advisable to create an excess of pressure in the auditorium. All leakage will then be toward the corridors and the stage. Under these conditions, with the raising of the curtain or the opening of corridor doors, disagreeable drafts are not created in the auditorium. As already pointed out, the air is generally supplied through numerous inlets in the floor of the auditorium or through the ceiling and walls.

Exhaust apparatus for removing the hot, vitiated air is usually important in theatres. Vents, placed in the walls and directly over the stage, provide a means of exit without giving the foul air an opportunity to drift toward the balconies or remain in the upper part of the auditorium.

The theatre need not be heated to as high a temperature as other buildings for obvious reasons. Upon entering the theatre, people are in street costume, and as a rule, have come from a considerably lower temperature outside. A low temperature, therefore, is sufficient when the theatre is first thrown open. Because of the close seating of the occupants, the auditorium will become heated several degrees in the course of an hour. It is, therefore, generally unnecessary to provide for heating after

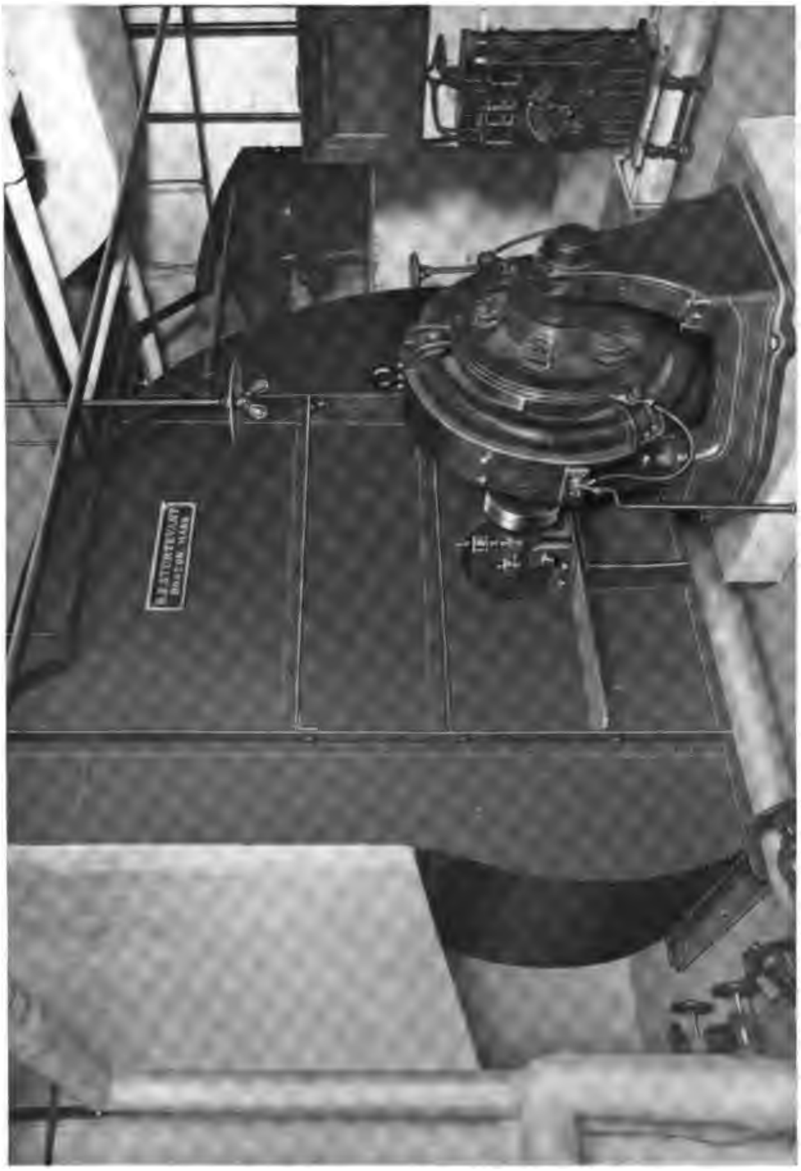

Fig. 66. Sturtevant Ventilating Apparatus in Century Theatre, New York City.

the performance is started. Once filled and thoroughly warmed, ventilation is of prime importance. It is usually more of a problem to cool than to heat the auditorium.

172. Moving Picture Theatres

The type of building that is often occupied by a moving picture theatre is not one well adapted to the housing of many people, as these buildings have often been designed for other purposes, such as stores. There is often no means of entrance for the air except through the front and rear, the ceilings are low and the building itself crowded and occupied continuously for hours at a time. Conditions in such theatres are extremely dangerous. Mr. M. T. Stevens, chief Sanitary Engineer of the Department of Health of Seattle, Washington, states that in moving picture theatres in Seattle the amount of carbon dioxide ranges from 6.25 to 34.5 parts in 10,000, conditions that are representative of many theatres in most cities. He further states, however, that by the use of electric propeller fans he has been able to reduce the amount of carbon dioxide in such places to 6.8 parts in 10,000 — an amount which insures good ventilation. Some proprietors have endeavored to better the conditions prevailing in their theatres by the use of ordinary electric desk fans, but their only success has been to stir up the air and create a draft without actually ventilating the theatre. In theatres too small to bear the expense of installing and operating a more complete ventilation system, an electric propeller fan, as indicated by Mr. Stevens's report referred to above, is an enormous aid. These fans are easily installed in the wall or ceiling of the theatre and exhaust air from the room. Fresh air is allowed to enter the building through the opening of doors. A positive change of air is insured by such an apparatus as this and by using a fan of proper size, any frequency of air change may be provided. Propeller fans should be located as far as possible from the inlet through which the air is to enter the room, in order to provide a movement of air throughout the entire building.

The largest sizes of the Sturtevant Ready-to-Run Ventilating Sets can be used to advantage in the ventilation of small theatres. By using one of these fans, the air can be taken from the outside and blown into the room, or the air of the room may be exhausted and blown out-of-doors. In either case, a positive change of air is supplied.

During cold weather, it is often desirable that the air entering a small theatre be warmed by passing over coils of steam pipes, radiator or heater of some description in order to guard against cold drafts.

The conditions met with in the operating booths of moving picture theatres are such as to necessitate mechanical ventilation. In most places, the law requires that the machine be inclosed in a fire-proof booth. The heat from the machine and the small size of the booth make it uncomfortable for the operator and make it necessary to resort to mechanical ventilation. It is usually arranged either to draw the hot, foul air from the booth by means of an exhaust fan or to force cool, fresh air into it.

The Sturtevant Ready-to-Run Ventilating Set has been widely used for ventilating these booths. The set is built in sizes that are well adapted to this work and because of its compactness and the simplicity of installing it, the set is much in favor for this work.

173. Office Buildings

The office building is a distinctive feature of the modern city. Its numerous rooms, of various sizes, are designed for a particular class of occupants. As a rule, the air provided per occupant is large, so that a fulfilment by the Sturtevant System of the requirement of heating is certain to provide incidentally an ample supply of air per capita for all purposes of ventilation. The physical inactivity of the occupants makes it necessary that a fairly high and equable temperature be maintained throughout the building.

It is evident that whatever the character of the heating and ventilating system, the control of the same for individual rooms must either be placed in the hands of the occupants thereof, or must be controlled independently for them, as by means of thermostats. Owing to the usual excess of air supply when heating is required as well as to the complications incidental to the introduction of a hot and cold system in a building of so many small rooms, this latter arrangement is seldom introduced. It is, however, usually a simple matter to apply it to certain apartments in which the requirements demand it.

In any office building, or in fact, any structure containing numerous small rooms, the multiplicity of flues necessary to provide independent supply for each room together with the frequent diversity of arrangement on the various floors practically forbids the construction of individual flues. Under certain circumstances, the outer walls of a building with symmetrical window arrangement may be utilized for the introduction of flues, but it is seldom that such opportunity is presented.

The only other resort and that usually adopted for distributing the air supply is as follows: — At a convenient point adjacent to the main corridor and as nearly central as possible, a vertical flue is provided. This need be merely of sufficient area to conduct the air at high velocity to the various floors; in fact, owing to the value of the space thus occupied, it is usual to make the velocity through this flue practically equal to that at which the air leaves the outlet of the fan.

The floor heights being ample, there may be introduced, just beneath the corridor ceiling upon each floor, a complete horizontal distributing system of galvanized iron pipe. Evidently such a system, in the majority of cases, must be rectangular in cross-section, seldom exceeding 15 inches in depth. Taking its supply from the vertical flue, each one of these independent sys-

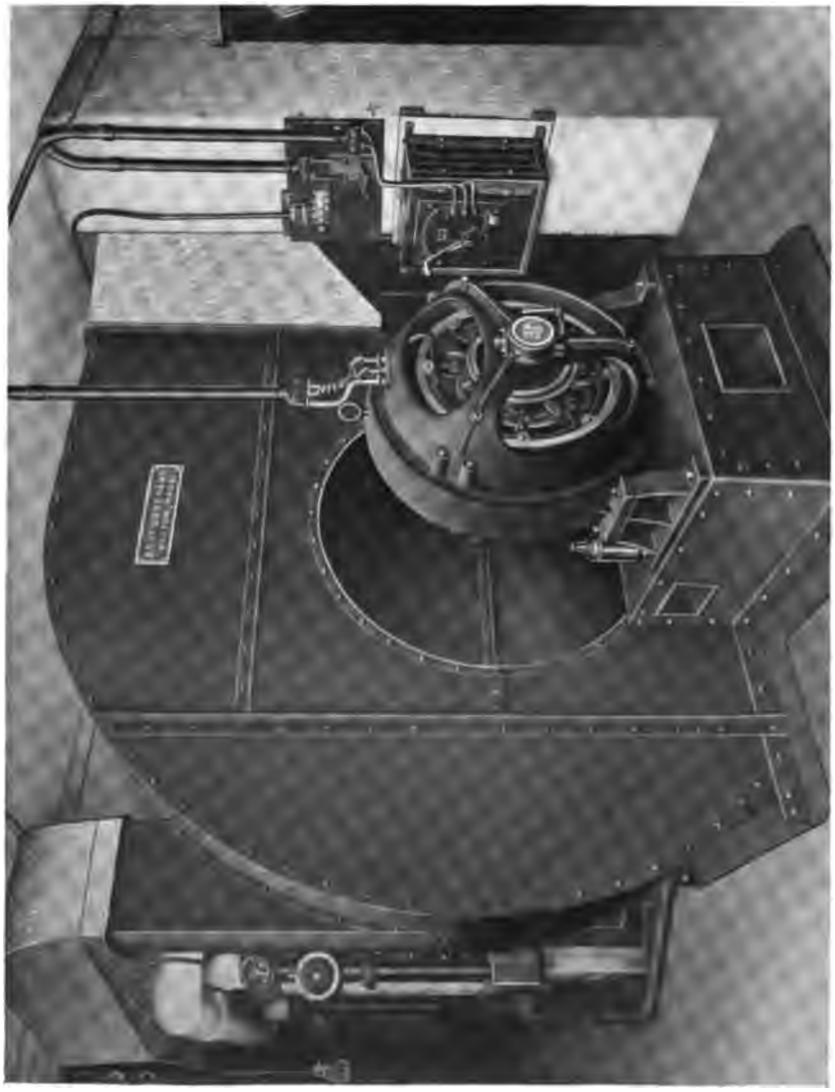

FIG. 67. STURTEVANT MULTIVANE FAN AND MOTOR, MISSISSIPPI VALLEY TRUST CO., ST. LOUIS, MO.

tems delivers air to all of the rooms upon its respective floor. It will be noted that numerous opportunities are offered, as at the connections to the flue, at the branch or a division near-by, at the separate branches to the rooms and at the registers themselves, to lower the velocity of the air sufficiently below that existing in the flue to secure its entry to the rooms with such relatively slow movement as to cause no drafts whatever. The finely finished interior of such a building naturally demands that no piping should be exposed to view. It is customary, therefore, to finish down below the pipe and its branches the entire width of the corridor, making thereby a false ceiling, but little below that of the adjoining rooms, so slight, indeed, that it is seldom noticeable. Of course, the character of such false construction will depend upon the material of the building itself. Usually it is of wire lathe and plaster, with the necessary cross supports of wood or of iron.

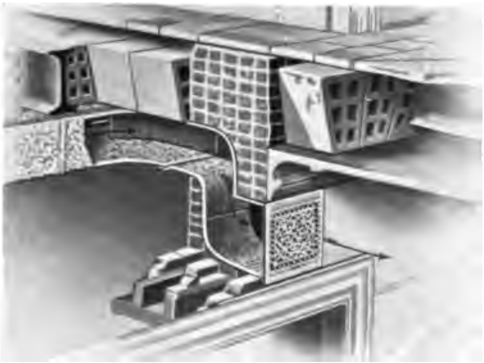

Fig. 68. Duct Arrangement in Office Building.

Additional heating surface is often provided in buildings of this character, so that the occupants may regulate the temperature to suit themselves. This may be placed in the base of the flues supplying air to the rooms in question, or in the rooms themselves. In either case, thermostatic control is possible and desirable.

174. Telephone Exchanges

Owing to the nature of the business transacted in telephone exchanges, it is usually necessary that the windows be closed to exclude noise and dust. Telephone operators are under a continuous nervous strain and the distraction of outside noise must be eliminated as much as possible, while the delicate instruments used are affected by the dust in the air being blown in through open windows.

The closed windows of a telephone exchange, therefore, make it necessary that there should be some very efficient method of supplying fresh air within the exchange. The Sturtevant System supplies an abundant quantity of air, cleaned of dust and warmed or cooled, as conditions of the office demand, and makes it possible for the windows to be closed, thus keeping out both noise and dust.

The installation of the Sturtevant System in an exchange is accomplished in much the same manner as in any office building or school, that is, with flues concealed in the walls of the room, discharging through wall registers.

175. Mercantile Buildings

In many respects the mercantile building does not differ greatly in its arrangement and requirements from the factory or shop. As a rule, large open floors exist, and the attendants are reasonably well separated. But to a greater extent than in the case of the factory, the side, and frequently the rear walls are blank because of abutting buildings. In fact, it is almost universally true that the store is most exposed upon the front. Show windows, however, with their inner sash or partition, serve as separate air spaces in a very beneficial manner to prevent the passage of heat.

In large wholesale houses there is seldom any obstruction above the level of the table or counters, but in some instances shelving is carried well up to the ceiling. Evidently it is essential, in planning intelligently a heating and ventilating system for such a building, that the final internal arrangements be known. Owing to the independent rental of individual floors in a building of this character, it is frequently the case that any information regarding the arrangements within the room, or even the business to be pursued cannot be ascertained in advance. Under such circumstances, the general scheme can usually be laid out so as to provide for easy additions in the way of galvanized steel distributing pipe.

In the majority of cases, overhead distribution is to be preferred, the air being discharged from flues in the inner walls toward the colder and exposed sides of the building. With a sufficient supply of air, ventilating flues are not necessary. In the case of a retail store, the constant passing of the customers in and out makes it extremely difficult to maintain the portion near the entrance at a temperature even moderately comfortable. Under the conditions of direct heating, the attempt is usually made to prevent the entrance of cold air directly to the store by the introduction of vestibules with double or triple sets of automatically closing doors, the vestibule proper being provided with large radiators. In effect, however, the numerous doors act like so many pump valves and the partial vacuum frequently produced in the vestibule compels an inward rush of cold air when the outer doors are opened. To overcome this difficulty, which is inherent wherever a direct heating system is used, it is evidently necessary to blow such large quantities of air into the vestibule that it will leak from the vestibule either into the store or out-of-doors as the case may be but in any case, preventing the admission of cold air from outside into the building.

176. Dwellings

While the Sturtevant System meets the requirements of domestic heating and ventilation, nevertheless, because of its mechanical nature, it is more or less unsuitable for introduction in a moderate sized dwelling. But in a large private residence or in the apartment house, where careful attendance is assured, it evidently surpasses any other method. Objectionable furnace gas is avoided, danger from leaking direct steam or hot water radiators cannot occur, and the supply of air is no longer at the mercy of atmospheric changes.

The electric motor will prove to be the most satisfactory form of drive for dwelling house heating system, since it requires less attention and is more susceptible of remote control, while for the heater, steam from any standard type of heating boiler may be used, thus minimizing the labor in connection with the care and operation of the apparatus.

Heating ducts and flues are concealed in walls and between floors or worked into the building as architectural features, as in office and schoolhouse installations.

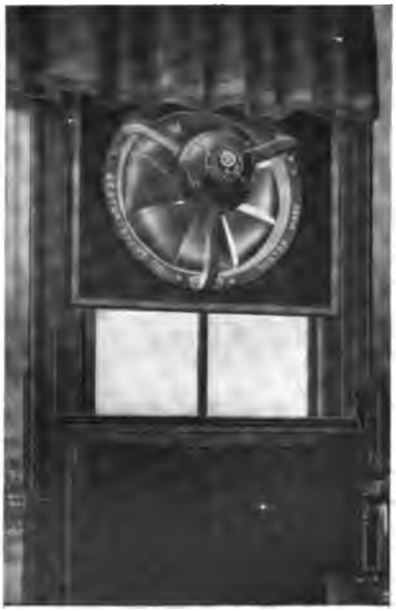

FIG. 69. ELECTRIC PROPELLER FAN INSTALLED.

177. Club and Smoking Rooms

The ventilation of club and smoking rooms is an important problem and usually becomes one of removing the smoke. For this reason, exhaust ventilation is the most applicable and is recommended as giving the greatest satisfaction. By providing exhaust ventilation, the stale, heavy, smoky atmosphere, so noticeable in poorly ventilated lounging rooms, is avoided, as the positive removal of all smoke and odors is assured by the positive action of the exhausting apparatus.

The room may be ventilated either through registers opening into vent flues that are connected to exhaust fans, or by locally installed exhaust apparatus, such as Ready-to-Run sets in small rooms or propeller fans in large rooms. The air change necessary depends upon the size, shape and arrangement of the room, the relation between the size of the room and the number of occupants, the amount of smoking done and other special conditions.

It is sometimes desirable to provide a definite point of admission for the air to the room. When this is done and if the air is brought in from outside, it should pass over a heating coil or radiator in order that it may be warmed properly before entering the room and in order that cold drafts may be avoided. The ideal system is, of course, a regular supply from a fan or hot blast heating system. In this case, the temperature, volume and cleanliness of the entering air may be controlled with ease.

Care must be taken, when removing air from club rooms, lounging and smoking rooms, not to remove so much air that the draft of the fireplace chimney is affected. Many installations are made with no attention to this detail, with the result that the draft of the chimney is absolutely " killed," making it necessary to supply fans to create a draft for the fireplaces.

178. Restaurants

It is most essential in ventilating a restaurant that the system be designed so that it is impossible for any of the air from the kitchen to enter the restaurant.

When the kitchen is below the level of the restaurant and well ventilated itself, this is not so difficult to guard against, but in case of a kitchen and restaurant directly connected, there is a possibility of a back draft through open doors which would carry the kitchen odors into the restaurant. In order to guard against this, the air exhausted from the restaurant is carried through the kitchen, creating a strong draft between the restaurant and kitchen, and, if the fans are always used, there is no possibility of this draft being reversed.

Some restaurants can be satisfactorily ventilated by means of an exhaust apparatus only, such as propeller fans set in the walls of the restaurant and drawing air from the restaurant itself. The propeller fan should be located as far as possible from the main point of entrance of the air, so that there is no stagnation in the room, and so that air currents may be set up from one end of the room to the other. It is sometimes necessary, in winter time, when doors and windows are closed, to provide some means of entrance for the air so that it may be controlled. By admitting the air over a radiator or a steam pipe coil, the cold drafts are eliminated and there is an opportunity for controlling the amount of air entering the room.

The frequency of air change in restaurants depends to a great extent upon the character of the room and the size of the room as compared to the number of people occupying it, making it impossible to give definite figures. By experience alone, the proper frequency of air change can be estimated. Where the restaurant ceiling is low, it would obviously require a more frequent air change than where the ceiling is higher. Where the tables are closely packed together, more air is necessary than in a larger restaurant. Where a great deal of smoking is done, it is necessary to provide a more frequent air change than in a restaurant where there is little or no smoking.

Large restaurants, such as hotel dining rooms and cafés, should be provided with the most modern apparatus and ventilating system. There should be provision made for exhausting air by means of a fan and for supplying air as well. The air should be properly warmed by heaters and tempering coils and should be washed by air washers. Some provision should be made in summer for ventilating and cooling the restaurant.

179. Kitchens

It is absolutely necessary that kitchens of hotels and restaurants shall be ventilated in order to remove the steam, cooking odors, heat and foul air from the kitchen and to prevent them from penetrating the other parts of the hotel or restaurant. For this reason, the exhaust system is generally used and a frequent air change is provided, so that undesirable odors and hot gases are forcibly and immediately removed from the kitchen and are delivered to the outside air through flues, such a strong draft being created that there is no possibility of foul air working back into the building.

Exhaust hoods over soup kettles and kitchen ranges are the most effective means of ventilating the kitchen. Wall registers, connected to vent flues, are also used as auxiliary means of clearing the atmosphere. The hoods are directly connected to flues, and the flues to an exhaust fan usually placed at the top. These exhaust vent flues are carried to the top of the hotel so that the discharge from them is above the rooms occupied by the guests. In some instances, the fan is placed at the bottom of the flue, on the level with the kitchen. The air is then blown, rather than drawn, up the flue.

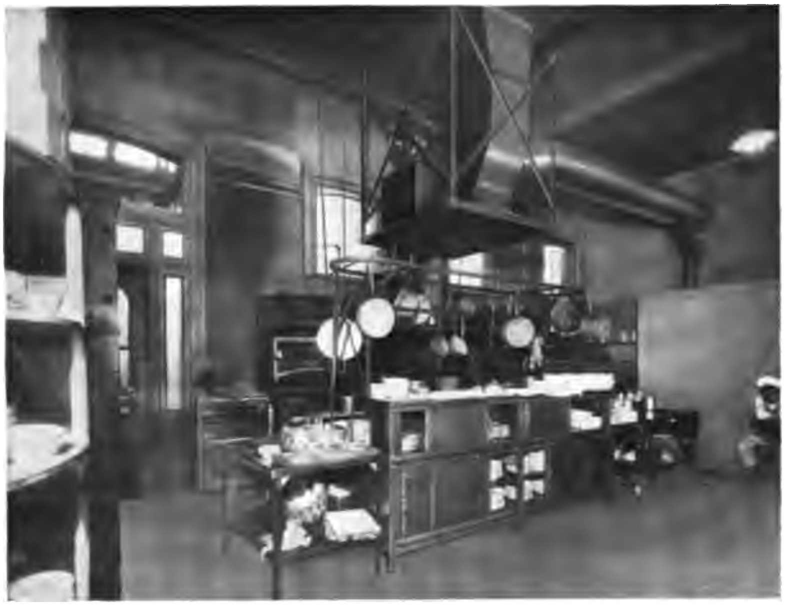

FIG. 70. STURTEVANT FAN EXHAUSTING SMOKE FROM KITCHEN RANGES.

In an ideal installation for ventilating kitchens, it is not only necessary to exhaust the foul air and cooking odors, but to supply fresh air as well. The air is supplied by a fan which draws it from the outside through an air washer, and in winter through a tempering coil, and possibly a heater, and discharges it into the kitchen. The air washer is a very desirable adjunct to any hotel ventilation system, as at all times it cleans the air of dust and dirt from the street, and in summer may be used for cooling the air.

The advantages of this double system of ventilation which provides both for a positive air supply and a positive exhaust, are obvious. With this arrangement, the point of admission of the air is under control, so that both the condition and the volume of the air may be regulated. The air washer and the tempering coil are essential in the best systems of ventilation. The frequency of air change that is provided for a kitchen is, of course, dependent upon the completeness of the ventilating system and upon the general arrangement of the kitchen.

180. Telephone Booth Ventilation

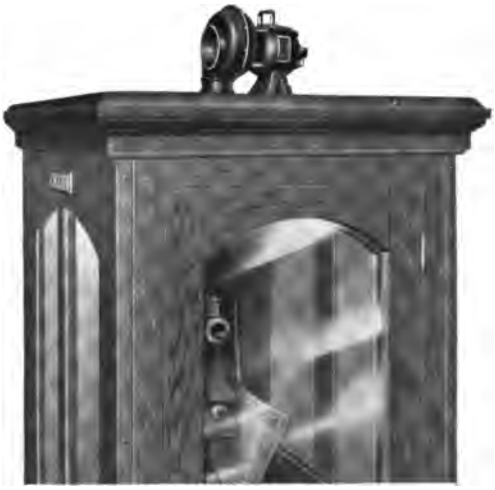

FIG. 71. STURTEVANT TELEPHONE BOOTH VENTILATOR.

The necessary tightness of construction of a sound proof telephone booth at once makes impossible any natural means of ventilation during the time of its occupancy. The Ready-to-Run Ventilating Set is very easily applied for the ventilation of telephone booths. Placed outside upon the top of the booth, the fan blows directly into it, a draft on the head being prevented by a suitable diffuser. Air leaves the booth through ventilator slides of brass in both inner and outer walls, so placed that no sound can be transmitted through them. The motors are run at a slow speed, to prevent disturbing noise. Where a number of booths are side by side, one blower is sometimes used to supply air to all the booths through a distributing pipe of fibre suitably finished. Sizes and capacities of blowers for single or multiple booth ventilation are given in Table No. 28.

Fig. 71 shows a single booth ventilated by placing the ventilator on top of the booth with the fan blowing into it through the diffuser.

Fig. 72 shows an arrangement made in the South Terminal Station, Boston, for ventilating a set of booths by means of one blower and fibre conduit.

181. Toilet Room Ventilation

Positive ventilation of toilet rooms in factories and office buildings removes obnoxious odors and ensures healthful and sanitary conditions. As the position of the toilet room often makes ventilation by natural means practically impossible and as mechanical ventilation usually provided ventilates the room as a whole and not the closets individually, the system devised by this Company is one that can be used effectively almost everywhere.

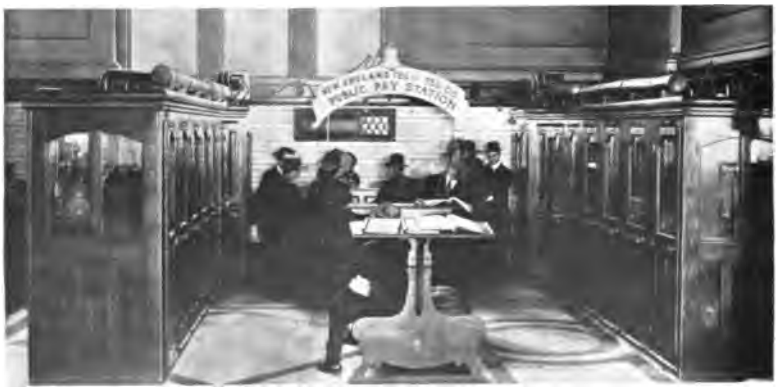

FIG. 72. VENTILATED TELEPHONE BOOTHS, SOUTH STATION, BOSTON, MASS.

Fig. 73 shows one of the Sturtevant Ready-to-Run Ventilating Sets in use, ventilating two closets which have been closed over the top with glass in order to admit light, while at the same time, allowing no air to enter the closet, except from below the half door, owing to the tightness of the covering. In this particular installation, a glass covering was necessary, but where closets are individually lighted, a cheaper material may be used.

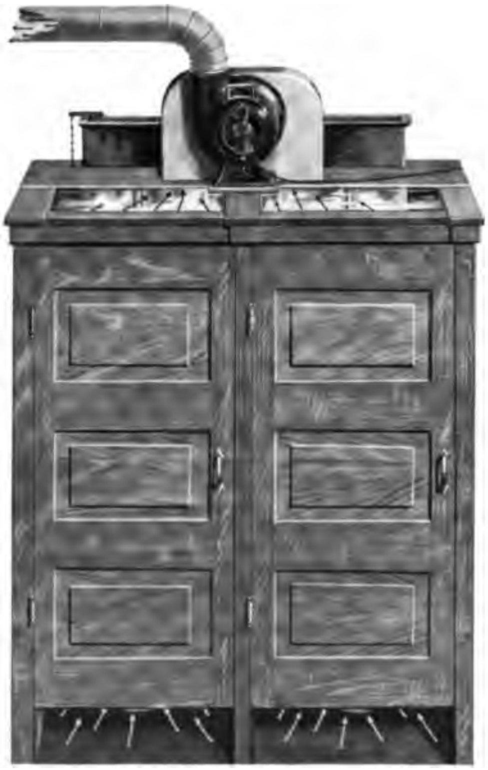

FIG. 73. METHOD OF VENTILATING TOILETS.

The inlet of the fan is connected to the top of the closet so that the air drawn in under the door is exhausted by the fan on the top of the closet and is then blown through a pipe connected to the outlet of the fan and discharging outdoors. Fresh air is thus supplied to take the place of the foul air which is being continuously exhausted. Individual closets or a number set side by side may be effectively and economically ventilated by installing a Sturtevant Ready-to-Run Ventilating Set.

182. Prisons

The requirements of a building designed for the confinement of criminals are peculiar to the building itself. In the most advanced construction, such a building includes, as its most important feature, the cell room or rooms variously arranged to the ideas of those in authority, but under all conditions containing a series of small rooms for the separate confinement of the occupants.

Owing to the character of the inmates, it is obviously desirable that the heating and ventilating system should provide no advantageous opportunity for escape, while the occupation of the cells, during at least one half of the twenty-four hours, requires that the maximum of air supply per occupant shall be provided. The separation of the prisoners, however, is such that the supply of air necessary to accomplish the heating under ordinary conditions is sufficient to meet all requirements per capita for the purposes of ventilation.

The cells are usually arranged in tiers, one above the other, either within an outer shell or building, or else abutting upon a well or corridor extending up several stories. To secure the requisite constant change of air, it must be evident, therefore, that mechanical means should be employed, and both plenum and exhaust fans should be introduced to secure the necessary equality in distribution.

183. Street Car Ventilation

There is no place where people are crowded into a small place where ventilation is much worse than in street cars. Owing to the fact that trips are not of long duration, poorly ventilated cars are tolerated and their evil effects are not easily noticed. People are, however, beginning to realize that these conditions cannot be allowed to exist and much has been done recently in advancement toward satisfactory ventilation along this line.

Sturtevant Ready-to-Run Ventilating Sets are being used for the ventilation of street cars. Air is drawn from outside, warmed by passing over a heater and is forced through pipes from which it is finally admitted to the car itself, thus performing the double duty of heating and ventilating. The fan is independent of both weather and the speed of the car. The warm air is constantly supplied and keeps the car at the proper temperature.

184. Railroad Coach Ventilation

Attempts at ventilating railroad coaches have been numerous but on the whole unsuccessful because all of the devices employed have depended for their operation upon the speed of the train. Therefore, they are satisfactory only when the train is in motion and do not operate at all when the train is standing in a station. As this is often the time when ventilation is most needed, due to the smoke and heat so abundant in the station, the automatic ventilator is undesirable as a sole means of ventilation.

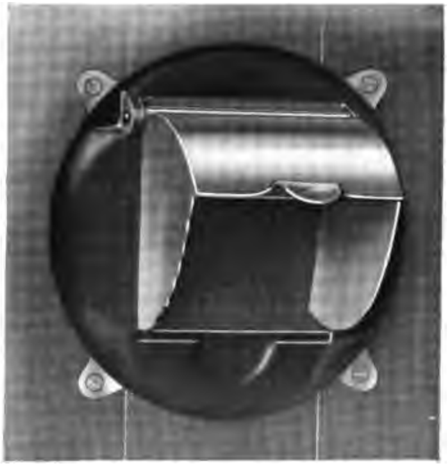

FIG. 74. ADJUSTABLE CAR VENTILATOR.

The use of electricity for lighting railroad coaches has made it possible to install automatic ventilating fans run from a storage battery or dynamo. The ordinary desk fan, however, which is used in many coaches, is satisfactory as a means of stirring up the air and creating a draft, but has practically no effect in actually ventilating the coach.

The Sturtevant Ready-to-Run Ventilating Set, on the other hand, is well adapted for this purpose of ventilating railroad coaches because of its small size and high efficiency. By means of one of these little sets installed within the coach and exhausting the air from it, almost perfect ventilation can be secured at all times, whether the train is moving or stationary, because the action of the blower is independent of the speed of the train.

For ventilating sleeping cars, it is arranged to blow air, which has been previously washed, heated and cooled, as the case may be, through galvanized steel ducts in the sides of the car, from which it is discharged through outlets placed in each berth and adjusted by the occupant. One of these adjustable ventilators is shown in Fig. 74. The occupant of the berth has under control the ventilation of the berth which he occupies and does not interfere with the comfort of his fellow passengers, nor is his comfort affected by their whims. At all times of the year and whether the train is in motion or not, an ample supply of fresh air is always at the command of the occupant.

The railroad dining car presents an important ventilating problem and one which is best solved by a system which is constantly in operation whether the car is moving or stationary. The system installed must ventilate both dining room and galley and must be arranged so that cooking odors cannot penetrate into the dining room. It is necessary to provide an independent ventilating arrangement for the galley on this account.

With mechanical exhausters electrically operated, the dining car can be ventilated while dinner is being prepared with the coach still standing in the train shed and when the coach is attached to its train, the atmosphere will be free from cooking odors. A successful system of ventilating dining cars and one which has been used considerably is a combination of the Sturtevant Ready-to-Run Ventilating Set with the Garland ventilator. With this arrangement the electric exhauster is in operation while the train is stationary or moving slowly. When the train reaches a certain speed, the electric exhauster is automatically stopped, ventilation being maintained by the action of the Garland ventilator whose operation depends upon the speed of the train. When nearing a stop, the blower is automatically started again and continues in operation as long as the train is moving at a slow speed or is stationary.

This combination has obvious advantages, as it uses the electric current only when the speed of the train is insufficient to bring the automatic ventilator into operation, and economy as well as effective and sufficient ventilation is thereby obtained.

As previously stated, the galley of the dining car is ventilated independently of other parts of the coach. A Ready-to-Run blower is installed in the upper part of the car and exhausts from a hood over the range. The cooking odors, smoke and fumes are expelled from the galley before they have an opportunity to penetrate into the dining car. The fan is arranged so that the fan wheel can be removed from the casing without disturbing other parts of the blower, which makes it possible to clean the grease and soot which accumulate on the blades and in the fan casing.

185. Steamships

The necessity of mechanical ventilation is as great in steamships as in buildings and has been applied to modern ocean liners, warships and steamships quite universally. The Sturtevant System is well adapted to this form of heating and ventilating, since it provides one or more compact units containing the heater and fan, for heating and ventilating the entire ship. There can be little doubt but that an abundant supply of fresh air for both passenger and the crew is one of the greatest luxuries of the modern ocean travel. With carefully designed systems of mechanical ventilation wherein the fan forces fresh air through ducts and piping to various parts of the ship, the atmosphere of the saloons and state rooms is maintained pure and fresh. Much of the discomfort of an ocean voyage, including seasickness, arises from the bad air which everyone is obliged to breathe when below deck with the air ports closed, as is often the case, especially in bad weather.

The problem is of equal importance in naval vessels, and the course of its inception and successful solution in the American navy has had a great influence in leading the merchant marine to adopt this most beneficent improvement.

In March, 1878, the Secretary of the Navy appointed a board of officers " to examine and ascertain the best system of ventilation by mechanical means or otherwise, by which the ships of the Navy may be more perfectly ventilated than at the present time." This board made an examination of the U. S. S. " Richmond " and reported: — First, upon the necessity of ventilation, showing " the filthy condition of the atmosphere generally on shipboard, which both men and officers are compelled to breathe; thus inducing disease, impairing health and increasing the mortality." Second, upon the necessity of some mechanical device to keep the circulation of air, giving reasons why " no system of ventilation can be relied on which depends for action on induced currents produced by the difference of densities or the difference in the static and dynamic heads of the internal and external air." As a mechanical device for ventilating, it was recommended " that a fan of the most improved type, and one that has been thoroughly tested and found efficient, be adopted."

Two fans, the first constructed for this purpose, were built by B. F. Sturtevant. After twenty-five days at sea, Chief Engineer Baker wrote: — " It may be confidently stated that the ' Richmond ' is now by far the most completely ventilated ship that ever sailed under the American flag, or indeed, under any flag." Since this beginning, all warships have to be equipped with ventilating apparatus providing air to the various parts of the ship.

CHAPTER IX

TYPICAL INSTALLATIONS

186. Installations of the Sturtevant System

THE following illustrations and descriptions are introduced here simply as being characteristic of the application of the Sturtevant System of Heating and Ventilation, and as the most fitting testimonials to the efficiency of the system and apparatus introduced by this Company. As has already been made evident, no two buildings require exactly the same arrangement, special modifications being necessary to meet special conditions. The different types have been selected with care, as illustrating the variations in requirements and the best means of meeting them in buildings differing widely in construction and uses.

Of course, it is not to be understood that these are the only arrangements of this system that could have been adopted in the different instances, but, under the conditions here given, they appear to be the best. To the reader, however, these illustrations will certainly be suggestive, and, it is trusted, will make still more evident the possibilities of the system, and render its application more intelligible.

Upon the following pages the various arrangements have been classified according to the type and character of the buildings in which they have been installed. All illustrations are from plants using Sturtevant apparatus and now in successful operation; they represent, therefore, actual working examples of the application of this system, and by their variety, bear emphatic testimony to the necessity of extended experience in deciding upon the best arrangement to be adopted. In other

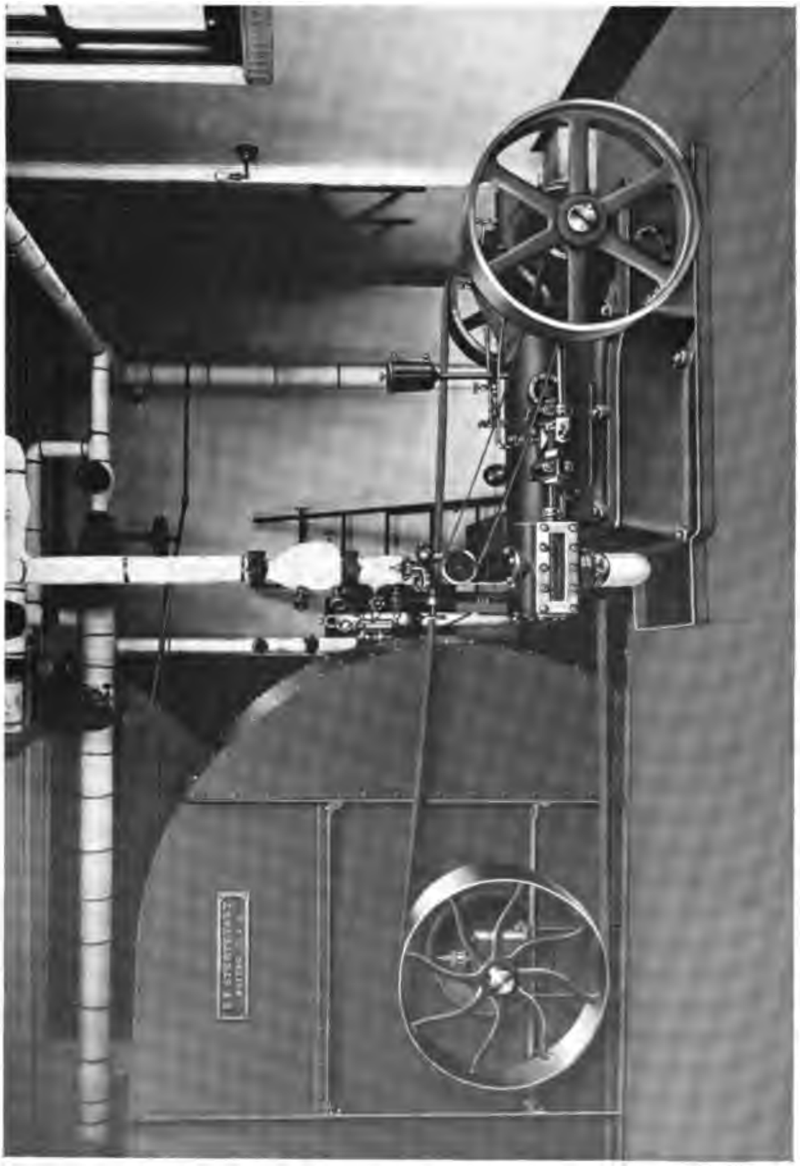

Fig. 75. Sturtevant Heating and Ventilating Apparatus, Adelbert College, Cinn., O.

bulletins and catalogs published by this Company are shown numerous examples of what has actually been accomplished in the ventilation of various types of buildings together with partial lists of buildings in which Sturtevant apparatus is used.

187. Burgess Mills, Pawtucket, R. I., Weave Shed

Fig. 76 shows the arrangement of one of the apparatus heating the weave shed of the Burgess Mills, Pawtucket, R. I.

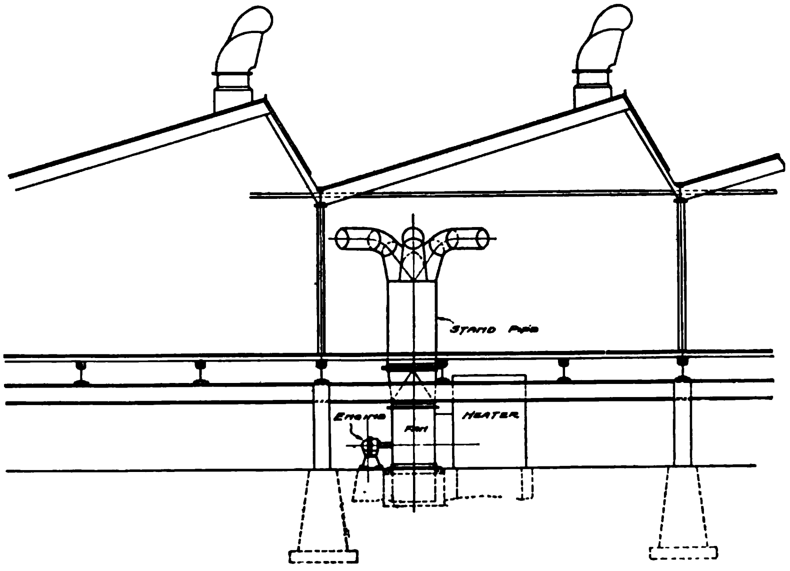

Fig. 76. Section of Burgess Mills, Pawtucket, R. I.

This building consists of a single story, 318 feet long by 250 feet wide, has a content of about 1,431,000 cubic feet, exclusive of the basement. It is liberally lighted by windows on the sides and by means of the saw-tooth roof.

Air from outside, warmed in the heater in the basement, is blown by the fan into the weave shed above, through a short, vertical stand-pipe fastened directly to the outlet of the fan and terminating in a series of horizontal discharge pipes which distribute the air in all directions. Although it generally requires more than one apparatus, unless the building be small enough to be served by one, this system is economical of piping and space. In such a low room and one which is filled with shafting and machinery, it is often difficult to run any system of distributing ducts through the building. The constant motion of pulleys and belting facilitates the diffusion of fresh air throughout the building, while ventilators placed on the roof provide an exit for foul air.

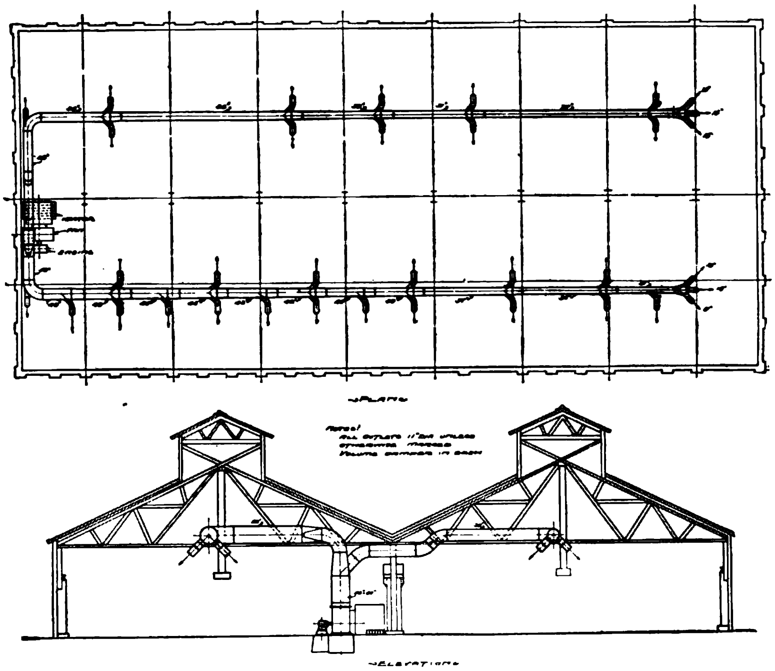

FIG. 77. LORAIN STEEL CO., JOHNSTOWN, PA.

Ventilation in such a building as this is generally of more importance than heating, because the body heat of the many people at work in the room raises the temperature enormously while their respiration vitiates the air rapidly. The evils of vitiated air have been carefully explained in a previous chapter and it is only necessary here to call particular attention to the fact that the Sturtevant System is beyond and above all others, the best, not only for employee, but employer, as the deleterious effects of vitiated air are more far-reaching than merely the immediate effects on the employee. A decreased sick list and greater efficiency among the employees is one of the returns on an investment made to install the Sturtevant System in factories and mills.

This system, as previously explained, is also applicable to buildings of more than one story when the arrangement here shown is reproduced upon each floor. In this case, the standpipe rises through the building from floor to floor, decreasing in sectional area as every set of branches is taken from it.

188. The Lorain Steel Company, Johnstown, Pa.

The bending and cold saw building of the Lorain Steel Company of Johnstown, Pa., is a single story building and entirely unpartitioned on the inside, making a single room. The roof is of the " M " type, each gable being provided with a monitor. The plan and elevation of this building, shown in Fig. 77,

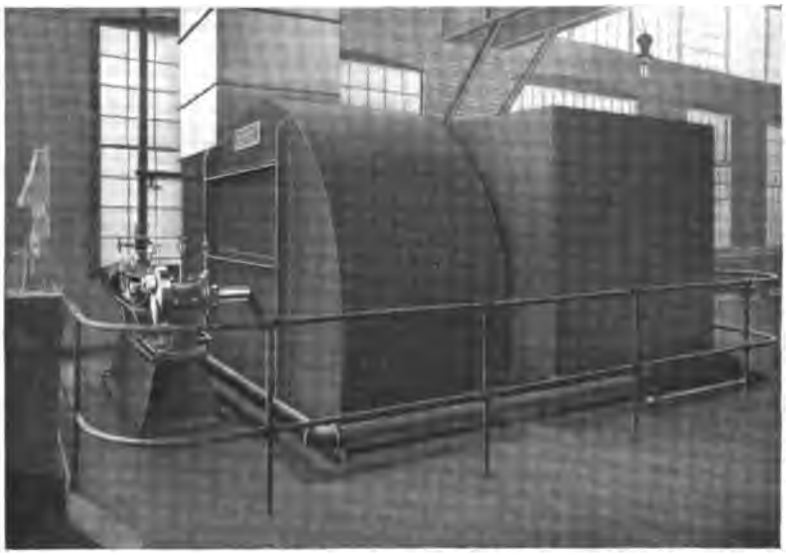

Fig. 78. Heating Apparatus, Lorain Steel Co., Johnstown, Pa.

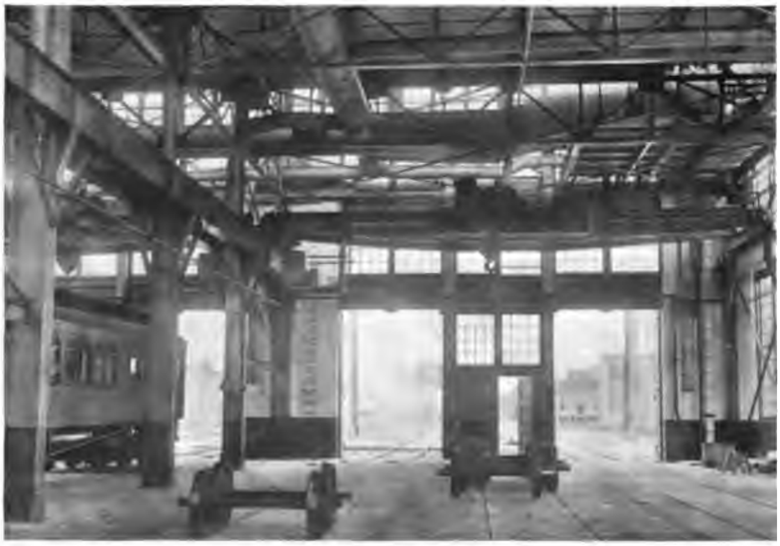

FIG. 79. HEATING ARRANGEMENT. FREIGHT CAR SHOP, D. & H. SHOPS, WATERVLIET, N. Y.

indicate the arrangement of the heating ducts and the location of the heating apparatus that was decided upon when the Sturtevant System was installed in the building.

The air in the shop is recirculated through a heater, as explained in Section 149, as ventilation is of little importance in a building of this type. A steel plate fan, drawing the air through a steam pipe coil heater which is jacketed to the inlet side of the fan, shown in Fig. 78, discharges vertically upward into a rectangular galvanized steel pipe. This pipe divides and the branches extend horizontally in opposite directions across the end of the building, where each division supplies a horizontal galvanized steel duct which runs the length of the building. This duct is carried upon the lower members of the roof trusses and is provided with short discharge pipes through which the air is delivered into the shop. These discharge pipes are so placed that the air is blown toward the outside walls and downward into the main body of the shop.

In a building of this type, the arrangement as here used is

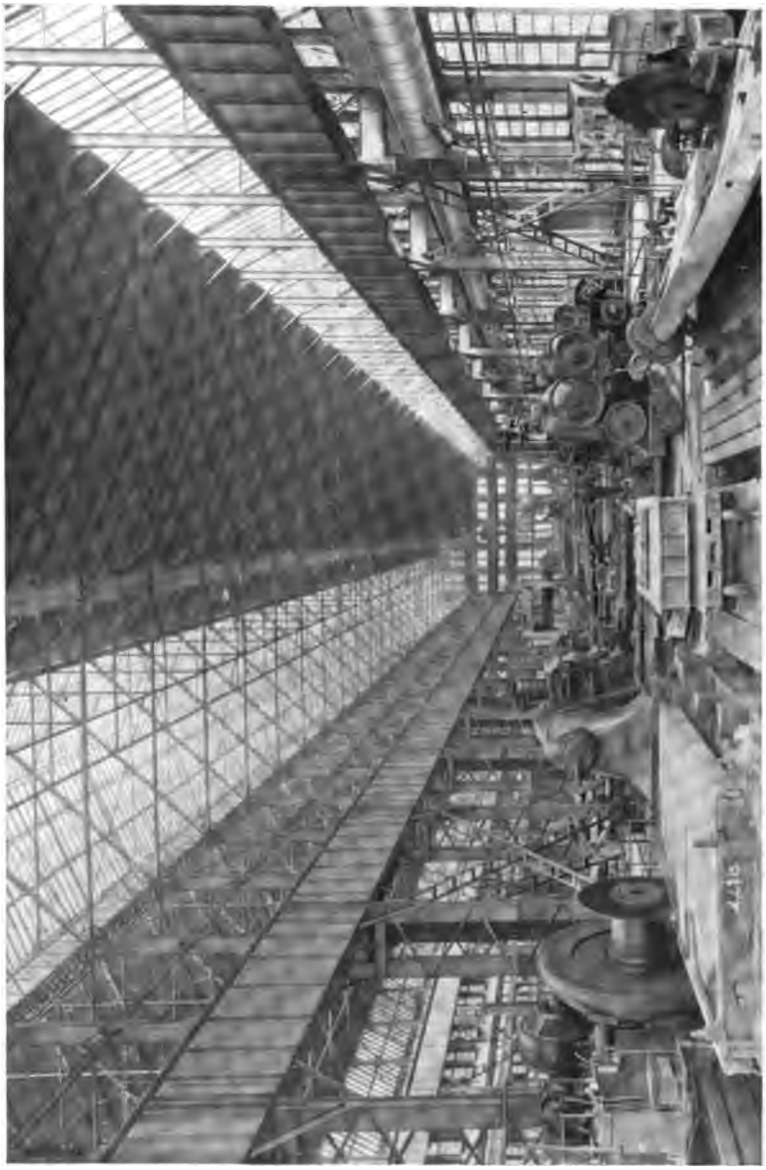

Fig. 80. Interior Ordnance Machine Shop No. 4, Midvale Steel Co., Nicetown, Pa. Showing Heating Arrangement.

especially desirable, owing to the cheapness of the construction and the ease of erecting the piping system. Located entirely above the lower members of the roof trusses, the galvanized steel piping is entirely out of the way of the two cranes which serve the entire floor area of the building. It will also be noticed that one side of the building, which is more exposed, is provided with a greater number of outlets than the other side which is protected by an adjoining building. In this way the greatest amount of air is blown directly into the coldest side of the building and the shop uniformly heated thereby.

189. D. & H. R. R. Shops

Another method of distributing air in a single story, single room building is plaintly illustrated in Fig. 79, which shows one end of the freight car shops of the D. & H. R. R. shops at Watervliet, N. Y. Here, all the available floor space is used for trackage, and the heating apparatus has been placed in the roof of the building where it occupies no otherwise useful space. In this building, as in most shops of this character, the cranes make it necessary to run an overhead system of piping above the lower roof truss members. The arrangement followed in this building for distributing the warm air is quite different from that just described. Here a more extensive system of piping is provided. From the main duct, branches lead to wall flues where the air is carried downward along the walls and blown into the shop through several outlets. These show quite plainly in the photograph. Another set of vertical flues is carried downward along the columns which support the roof in the centre of the building. These flues discharge in two directions, toward the outside walls, and are fitted with hand operated volume dampers. The shop is thus well supplied with warm air from the centre and from the inside walls.

Arrangement is made whereby fresh outside air can be used in the heater if desired by providing a louvred opening connected

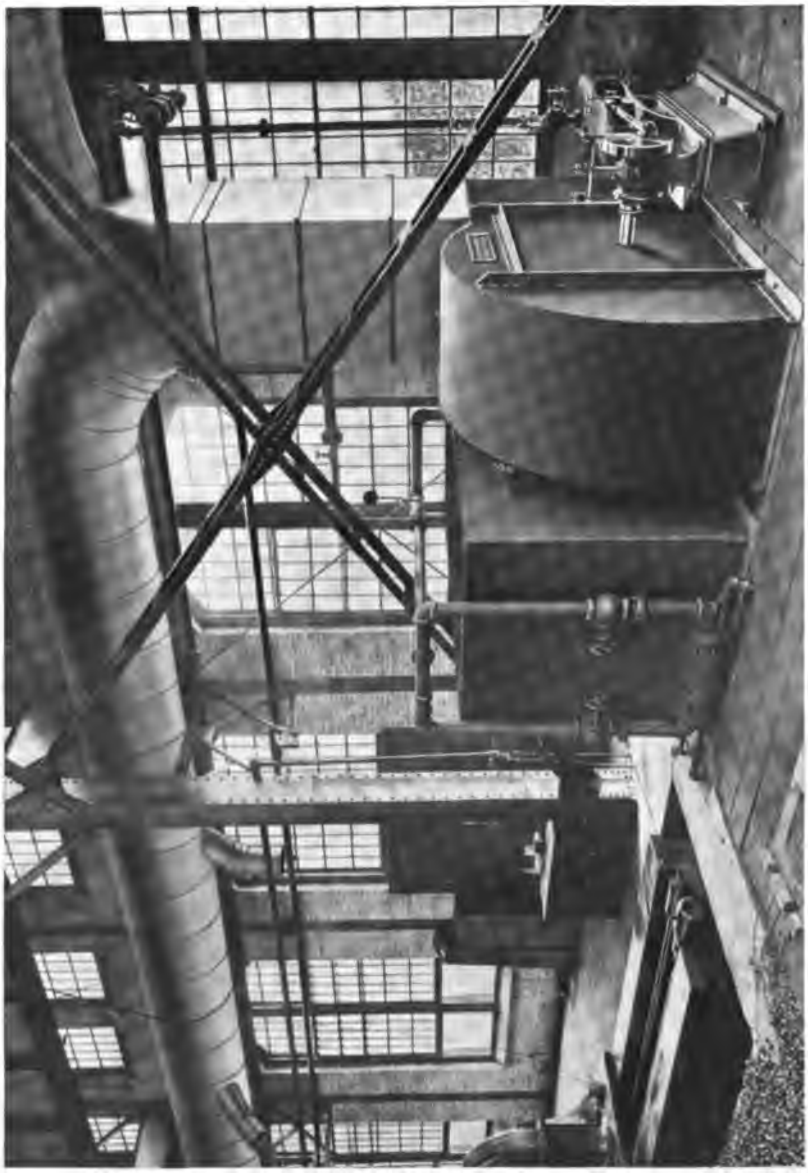

Fig. 81. Sturtevant Heating Apparatus, Ordnance Machine Shop No. 4. Midvale Steel Co., Nicetown, Pa.

to one end of the heater. Two separate apparatus are used in this building, being placed at opposite ends of the shop. Each apparatus supplies air to an individual system of distributing ducts. Although this arrangement necessitated considerable galvanized steel piping, the conditions under which it was erected were especially favorable, as the piping could be supported by the roof trusses.

190. Midvale Steel Company

Still another arrangement for heating a single story building is indicated in the two illustrations shown in Figs. 80 and 81. Here, as in the other examples already cited, an arrangement of pipes is necessary that does not interfere with the space provided for the crane. The arrangement followed in the two previous cases would have been difficult to follow in this, owing to the height and construction of the building. This arrangement provides for a single galvanized steel duct that runs entirely around the building on the inside, close to the wall. The short discharge pipes, through which the air is blown into the building, are directed downward and toward the centre of the building. The air has a general movement toward the centre of the building where it rises and escapes through the windows which light the centre of the shop. In order to guard against too large an apparatus and one that would have to force the air too great a distance, four apparatus are used. They provide a thirty-minute air change in the shop which contains about 5,250,000 cubic feet of space. As ventilation is a matter of only secondary importance in a shop of this character, the apparatus are arranged to recirculate the air for greater economy in operation.

191. New York Shipbuilding Company

When the machine shop becomes very large and high, as is often the case where large machines are used, it is not

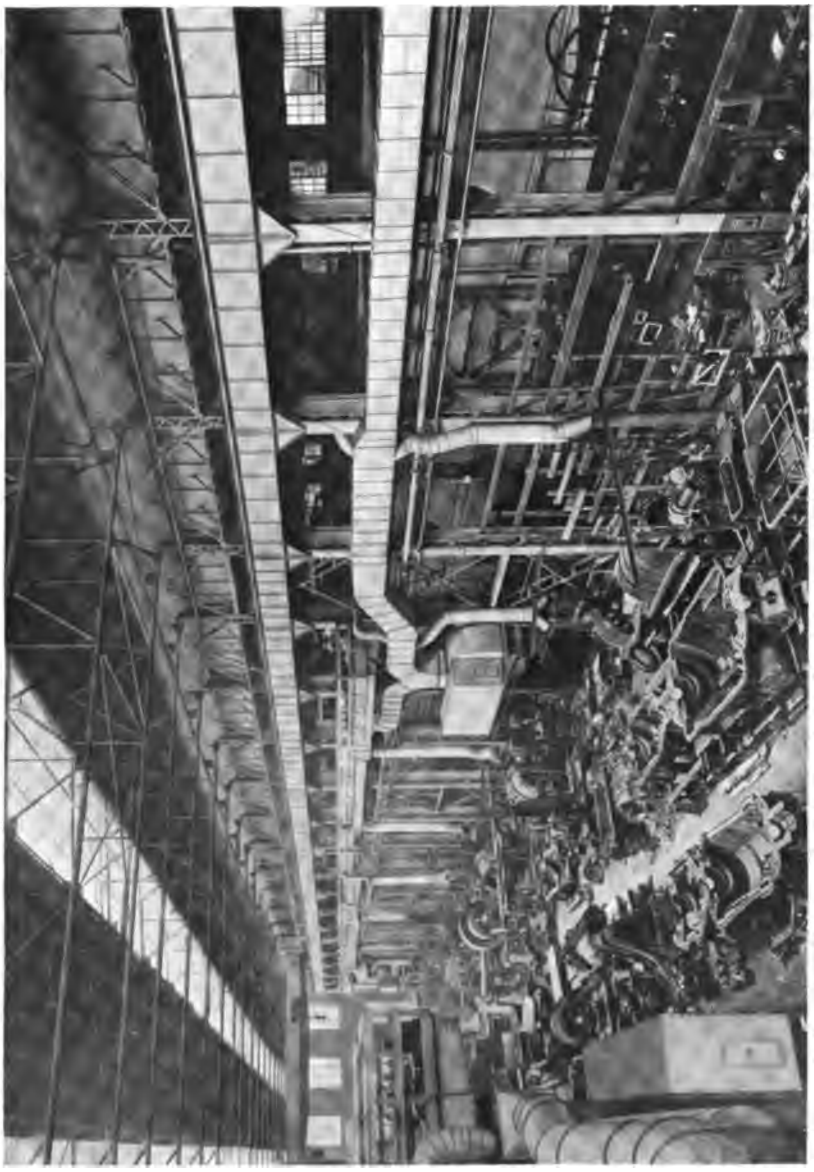

FIG. 82. HEATING ARRANGEMENTS, N. Y. SHIPBUILDING CO., CAMDEN, N. J.

uncommon practice to provide galleries along the side of the shop.

While this does not in the strictest sense of the word create a building of more than one story, as the gallery is generally open on the inside, yet it is generally necessary to provide a direct means of entrance for the warm air into the gallery and below it as well.

The method of distribution for such a building generally differs from those already discussed. Fig. 82 shows how such a building has been heated by the installation of the Sturtevant System. Four apparatus, three of which can be seen in the photograph, were necessary to heat this shop. As in the case just cited, it was considered more economical to install four apparatus rather than one or two.

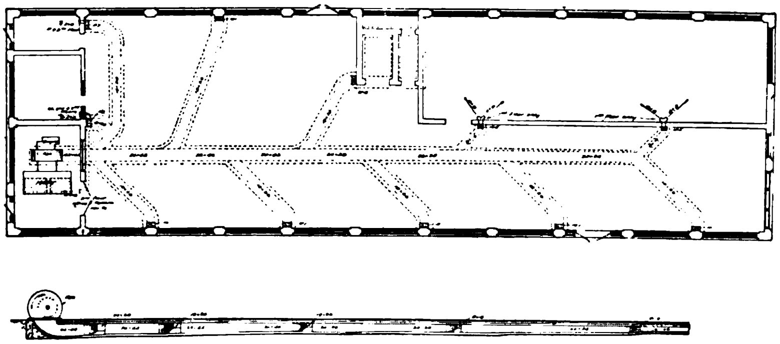

FIG. 83. PEERLESS MOTOR CAR CO.

The apparatus are located on specially constructed platforms midway between the floor of the main shop and the galleries, and each supplies warm air to a separate duct system. One main duct is employed which is placed on a level with the gallery floor. From this duct galvanized steel pipes lead downward along the steel columns and blow air into the shop below, while short discharge pipes supply air to the gallery.

It will be noticed that the duct shown here is rectangular in cross-section. This is preferable where such a large duct is

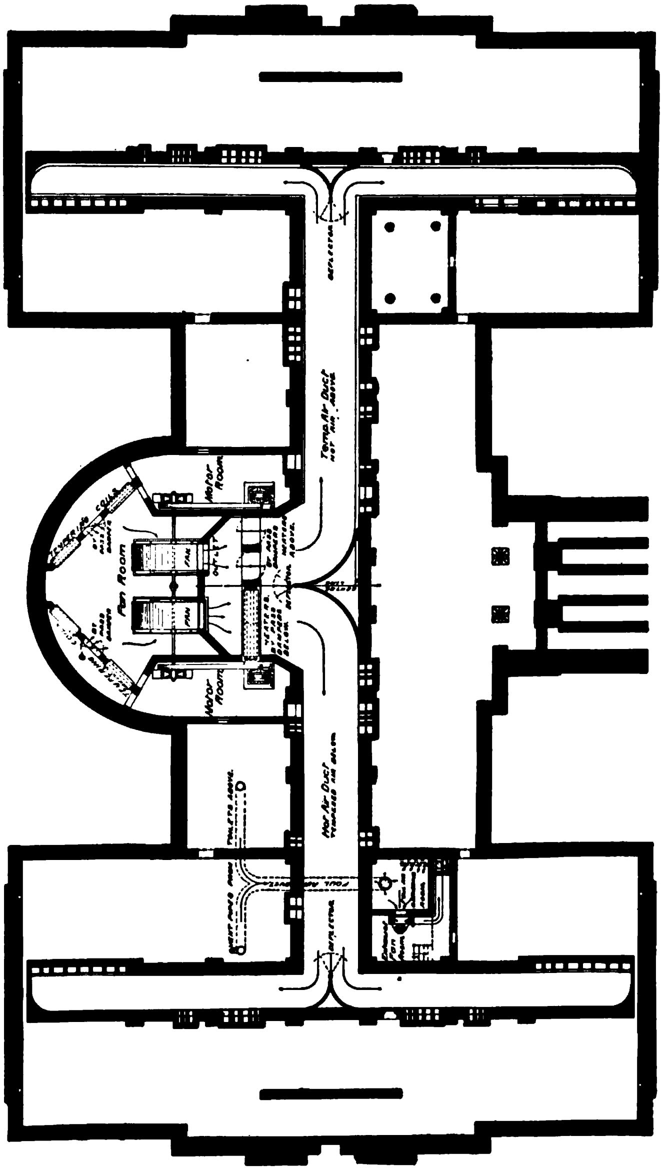

FIG. 84. BASEMENT PLAN, STATE UNIVERSITY OF IOWA, PHYSICS BUILDING.

used, as it can be easily braced and consequently will hold its shape better than round piping and can be constructed of lighter gauge galvanized steel. The air of this machine shop is all recirculated, as, compared with its size, there are relatively few occupants.

192. Peerless Motor Car Company

An entirely different method of distribution than those previously described presents itself in the arrangement which was followed in one of the buildings of the Peerless Motor Car Company. Fig. 83 makes clear the arrangement of the underground ducts and the location of the flues. Unlike the buildings previously described, this one has many floors and the heating arrangements must take into consideration this fact. The system as finally installed consisted of wall flues, which distributed the air to the various floors of the building and which were supplied with warm air from an underground duct of concrete. Such a duct is shown in Fig. 35. The arrangement is one that can be applied to either a single or a multi-story building with equal success. In either case, it does away with a large amount of galvanized steel piping. When overhead space is lacking, or where belts, shafting, cranes or some other obstructions interfere with the installation of a galvanized steel piping system, this arrangement has obvious advantages. The flues may either rise in the walls, being concealed in pilasters, or galvanized steel flues may be installed close by the outside walls of the building. It will be noticed that the underground duct employed in the building runs down its centre with branch pipes leading to the various flues which are located on both sides of the building. In multi-story mills, where the entire floor is one room, it is generally customary to build flues on one side of the building. This arrangement cannot be followed if there are partitions dividing the floor longitudinally into more than a single room, hence an arrangement like that of Fig. 83 is followed.

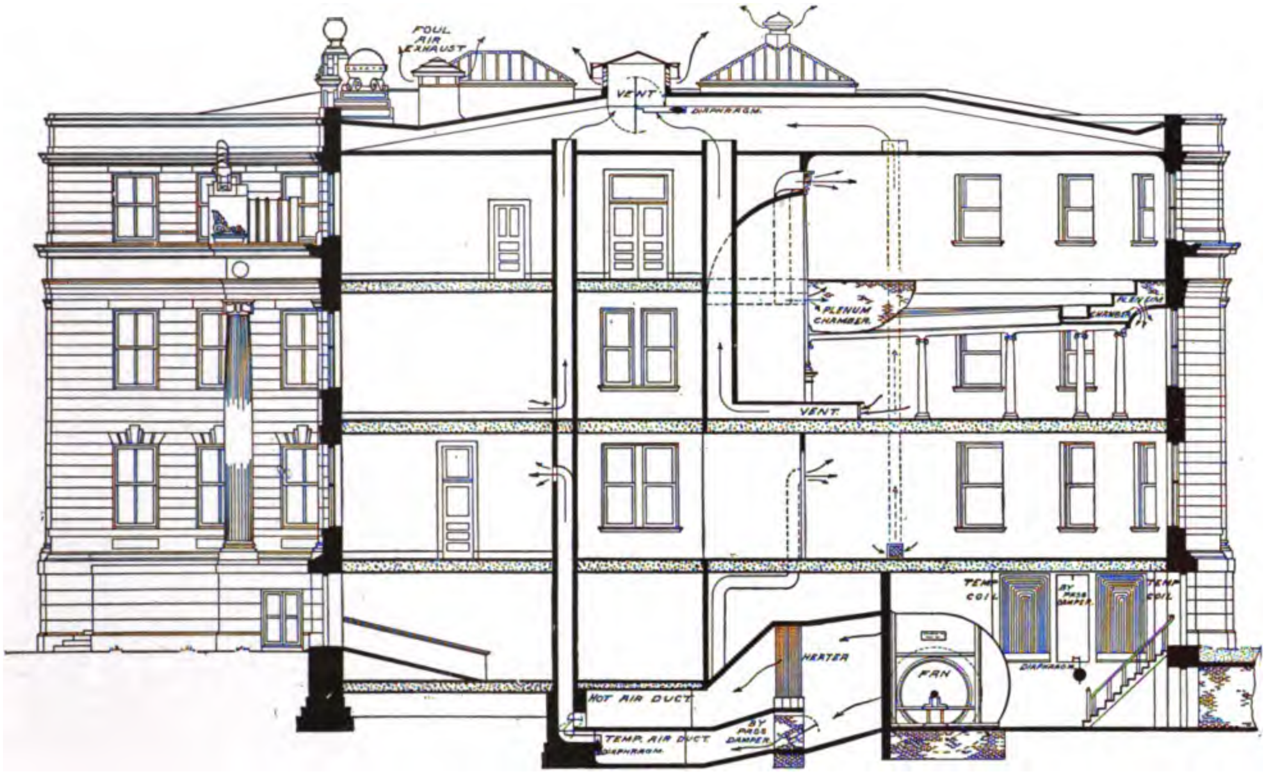

FIG. 85. HEATING AND VENTILATING ARRANGEMENT, VERTICAL SECTION OF BUILDING.

193. State University of Iowa

From Figs. 84 and 85 can be obtained a comprehensive idea of the arrangement of the Sturtevant System when applied to a building where the requirements for heating and ventilating are equally important and where the greatest refinement, both in design and operation, is necessary. Here the elevation and plan views of the Physics Building of the State University of Iowa are shown, arrows having been placed upon the elevation view to indicate the course of the air in its path into, through and out of the building.

The air enters the building from the outside through screened openings that are situated in the basement and hidden in the elevation view by the tempering coil, but which are shown in the plan view. It then passes through two tempering coils and through a by-pass which is located between the coils. This by-pass is operated by a pneumatic diaphragm which is controlled by means of a thermostat, so that variation in the temperature of the building regulates the amount of air passing through the by-pass or tempering coil. The air is drawn from the tempering coil into the fan and blown through a second heater or through a by-pass below this heater into a double duct which is constructed of concrete and laid below the basement floor. The duct is shown in outline in Fig. 84.

Air from this double duct enters flues which are located in the walls of the building and rises in them, entering the various rooms through registers placed in the walls about 8 feet above the floor. These are shown in the sectional view. Diffusing throughout the room, the air becomes cool and sinks. The vitiated air then leaves the room through registers located in the walls near the floor and opening into the vent flues which carry the air to the attic, where it is allowed to escape to the atmosphere through ventilators.

The double duct contains heated air above and tempered air below. The temperature of the air leaving the room is regulated by mixing varying quantities of heated and tempered air at the base of the flue. As previously explained, this mixing is accomplished by means of mixing dampers controlled by pneumatic diaphragms that are regulated by thermostats placed in the rooms themselves.

The deflection dampers, which are placed at points in the duct where the direction of the air is changed, are for deflecting the air into its proper channel. They are adjustable as previously explained and can be set after the heating system is in operation so that the proper amount of air is delivered to each set of flues.

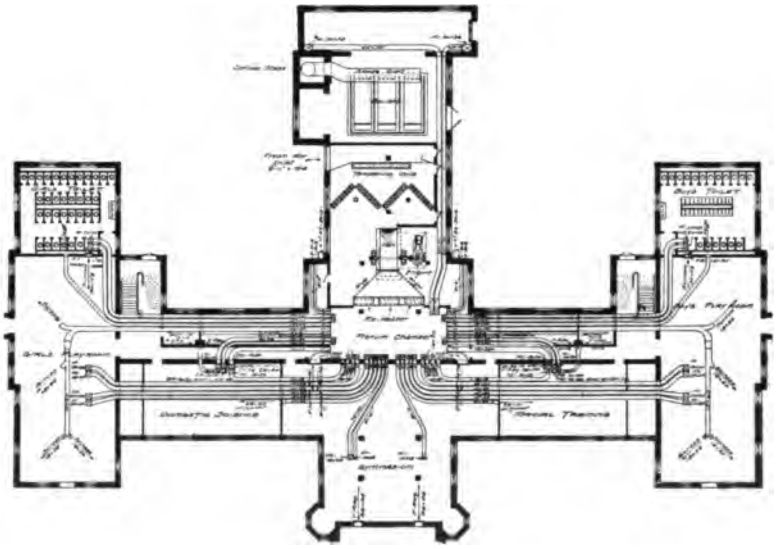

FIG. 86. AVONDALE SCHOOL, CINCINNATI, O.

This system, with modifications to suit conditions of arrangement and size, is employed quite generally in public and school buildings. The following examples illustrate how the application has been made in a few buildings typical in their purpose and in the application of the Sturtevant System to them of the many types of buildings to which this system may be successfully applied.

194. Avondale School

A modification of the arrangement just described and one that was followed in an installation in a public school is shown in Fig. 86, which is a plan view of the basement of the Avondale Public School, Cincinnati, Ohio. The underground concrete duct employed in the previous installation is replaced in this by a galvanized steel distributing system. The double duct or plenum chamber is also changed, for a smaller plenum chamber, divided to contain warm and tempered air and individual, single ducts, lead to the bases of the various flues. The ducts are rectangular in cross-section and are suspended from the ceiling of the basement, the arrangement being economical of space and easy to install.

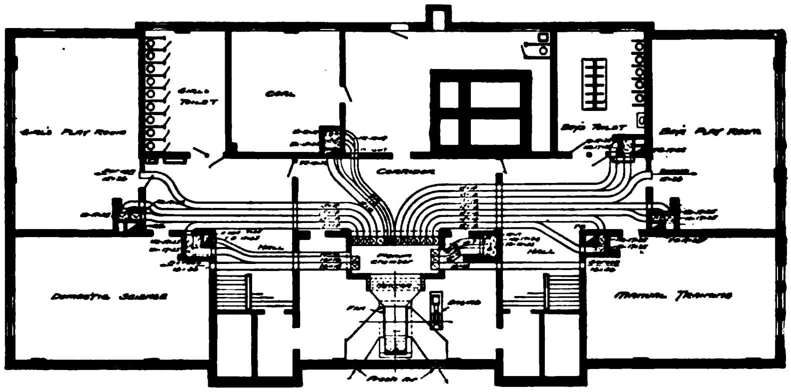

FIG. 87. TYPICAL SCHOOL HOUSE ARRANGEMENT.

The air is drawn through a screened opening in the basement, is warmed by passing over a tempering heater and is cleaned by being drawn through an air washer. The fan then blows this washed, tempered air through a reheater or through a by-pass under the heater into a divided plenum chamber. The upper part of this chamber contains the warm air and the lower part contains the tempered air. Automatic regulating dampers thoroughly mix the warm and the tempered air as it passes through these chambers into the heating ducts, thus regulating the temperature of the air supply without affecting the volume delivered. The flues are concealed in the walls of the building, carrying the air from the ducts to the various rooms.

In the rooms, the air is admitted through registers placed in the walls 8 feet from the floor, while the vitiated air escapes through vent flues as described previously. The air supplied provides an average of about 30 cubic feet of air per pupil per minute or 1,800 cubic feet per hour.

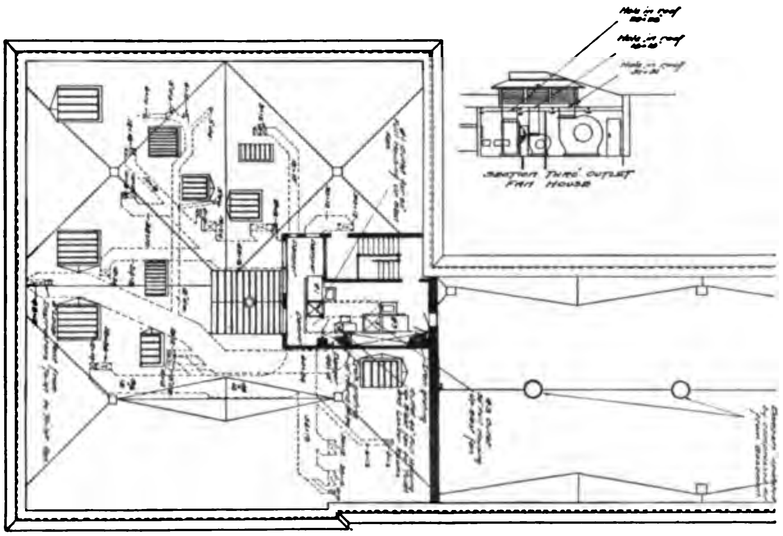

FIG. 88. ATTIC PLAN, HARVARD DENTAL SCHOOL, BOSTON, MASS.

Another arrangement of heating ducts in a school building is shown in Fig. 87. This is a smaller school and one that is more compact than that just described. The same arrangement of plenum chamber and single air ducts to individual flues is used in this installation.

195. Harvard Dental School

A building similar in general character to those just described but differing as to detail is the Harvard Dental School. Here, the question of the removal of vitiated air was as carefully considered and as positively provided for as the supply of fresh air. The system as installed has both a supply and exhaust apparatus, with the result of obtaining the best ventilation possible.

The drawing in Fig. 88 shows a plan view of the attic of the Dental School and indicates the location of the apparatus providing for the removal of the vitiated air. It will be noticed that this apparatus, consisting of three motor-driven exhaust fans, is located in the attic of the building and discharges to the atmosphere through a louvred pent house covering the fans and motors. These exhausters draw the air from the building through vent flues and ducts that are connected directly to the inlet of the fan. While in some cases the open attic space is used as a gathering room into which all the vitiated air from the building is discharged and from which this same air is removed by a fan, this arrangement is not to be preferred, as the effectiveness of the fan is impaired by drawing from so large a space due to the vast amount of leakage that necessarily takes place through the roof. The fan is, moreover, more efficient as an aero-motive force when the velocity pressure imparted to the air can be maintained by confining the air in a pipe or duct.

In the basement of this building there are also three fans which supply air to the rooms. The air is filtered and heated before being blown into the ducts which convey it to various parts of the building. For exhausting the fumes and odors from the laboratory and laboratory hoods, there are two monogram exhausters used. This method of ventilating laboratories by positively removing the fumes is the most successful that can be applied, as such strong currents of air can be created that the odors are removed before they have an opportunity to diffuse throughout the atmosphere of the laboratory.

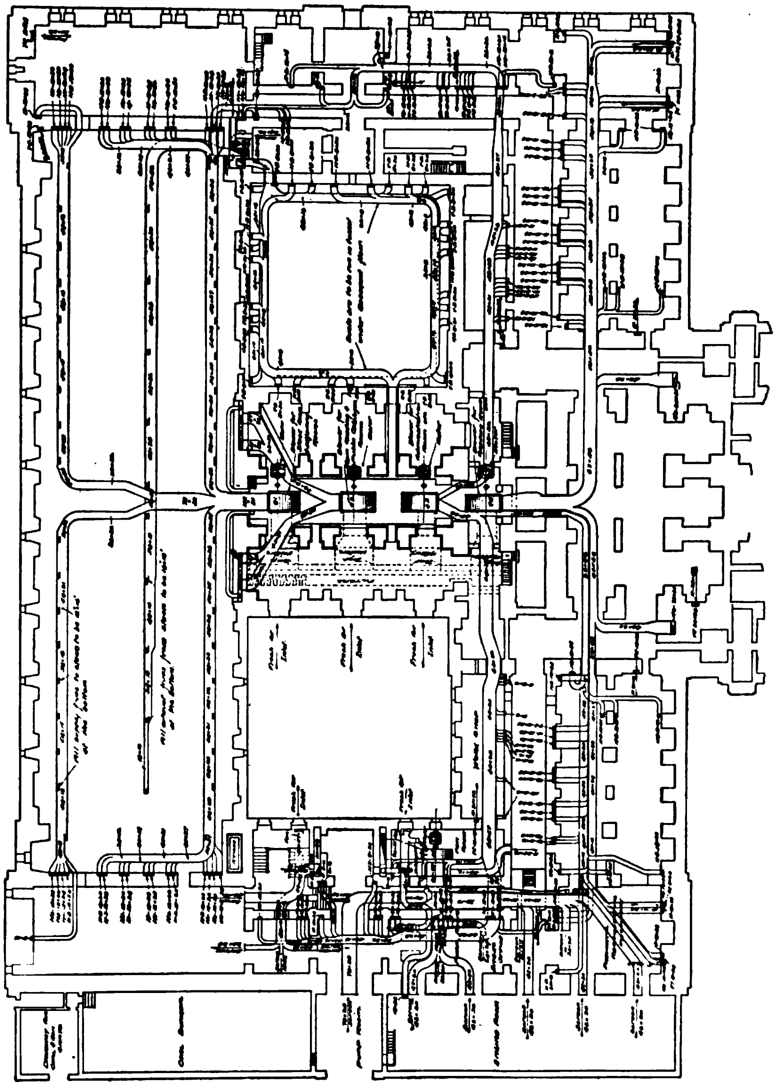

FIG. 89. BASEMENT PLAN, NEW YORK PUBLIC LIBRARY, NEW YORK CITY.

196. New York Public Library

While the arrangements described previously and which were followed in schools and buildings of a similar character answer the purpose in that particular class of buildings, there is necessary a more complicated arrangement and a different disposition of apparatus in large government and municipal buildings. The character of these buildings is such as to necessitate the best system and arrangement that can be devised, and requires the highest engineering talent in designing it. These buildings are, as a rule, highly decorative on the interior, a condition demanding the skill of the engineer and architect to introduce the system without inharmonious effect. Moreover, as they are divided into many rooms and corridors and extend over considerable ground area with sometimes a height of several stories, a complicated duct system is inevitable. Such buildings should be attempted by trained engineers only, as the problems met with can, as a rule, be solved by experience and special training only.

The New York Public Library is a typical example of this type of public building. In Fig. 89 is a plan view of the basement in which is given a general idea of the location of the apparatus and the layout of the distributing system. Here we find four apparatus supplying heated air to the building. These are centrally located on the right side of a central court from which the air is taken, it being drawn through filters.

Practically, there are two buildings, each of an entirely different character, to be heated — the main building and the stack room. Apparatus No. 1 is for heating the stack building. This is several stories high and is two city blocks in length. The arrangement of the heating ducts is shown on the drawing. A duct, running through the middle, provides for the exhaust from the stack and adjoining reading rooms, while a branch duct from the fan supplies the warmed air.

The air for ventilating the stack is drawn from the neighboring court by a fan through an air filter and tempering coil. It is then blown through or by-passed around a reheater by means of which the temperature of the air is raised to the required degree, blown into the duct mentioned above and distributed to the various parts of the stack. The vitiated air leaves by means of the exhaust duct and is conducted to a vent flue from whence it is expelled.

Apparatus No. 2 is an exact duplicate of No. 1, so far as size and arrangement of fan, tempering coil and reheater are concerned. The distributing system, however, is considerably different. The air is for a supply to the main reading and catalog rooms which are located upon another floor.

Apparatus No. 3 is arranged similarly to Apparatus No. 1, but is slightly smaller. The fan supples air through the piping system, shown in the drawing, to the administration room and corridors.

The arrangement of Apparatus No. 4 is similar, though the apparatus itself is smaller than Apparatus No. 1. The fan supplies air to the reading rooms in the front of the building by means of a system of galvanized steel ducts indicated in the drawing.

All four of these fans are driven by direct connected electric motors and galvanized steel is used for the ducts entirely. The heaters and tempering coils are of the Sturtevant mitre type and the fans are Sturtevant steel plate exhausters.

The power and other mechanical equipment for the building are situated in the basement at the 40th Street end. For exhausting the hot and foul air from the engine and pump rooms, Apparatus No. 5 is used. This is an exhaust fan connected to a system of exhaust piping as indicated in the drawing and discharging into a large vent flue. A monogram exhauster, marked on the drawing as Apparatus No. 6, is used for removing the fumes from the storage battery room. Two systems of ducts with fans are also provided for ventilating and cooling the engine and boiler rooms.

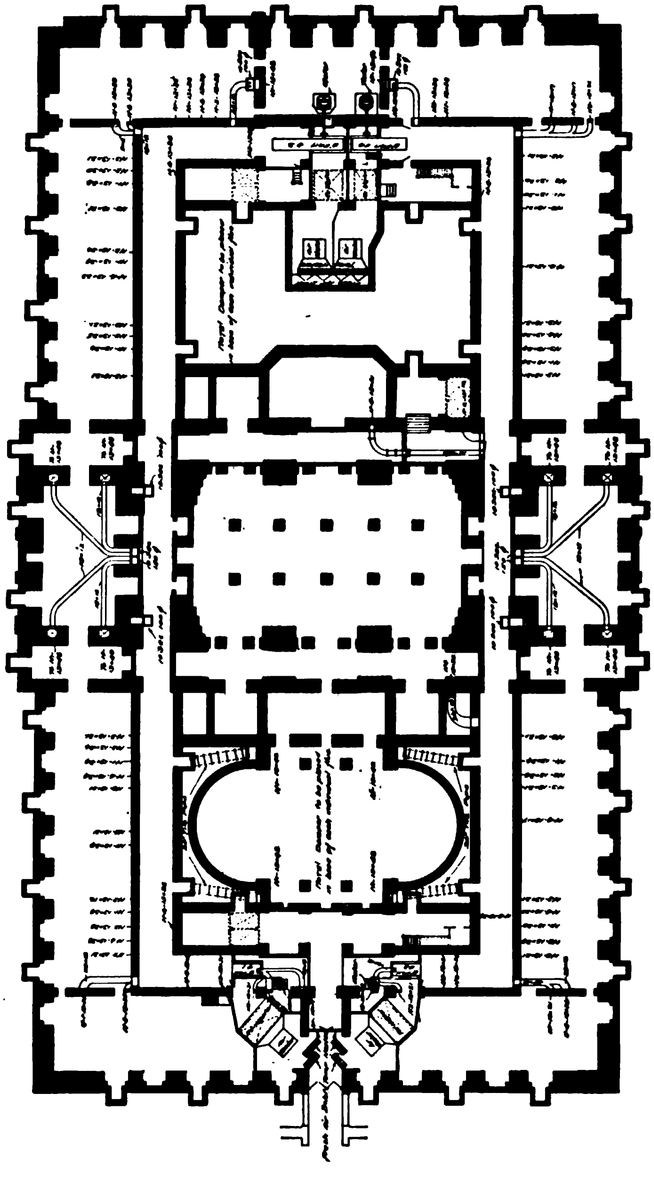

FIG. 90. CUYAHOGA COUNTY COURT HOUSE.

197. Cuyahoga County Court-house

In contrast to the galvanized steel duct system used in the New York Public Library just described, is the single concrete duct arrangement of the Cuyahoga County Court-house building in Cleveland. Here there are two sets of apparatus, one at each end of the building and each consisting of two fans, heaters, air washers and motors, making four supply apparatus in all.

The concrete supply duct is laid in the form of a rectangle following in outline the contour of the walls of the building. The air enters the building through fresh air inlets, as noted on the drawing, and passes through tempering coils which warm it to a moderate temperature before it enters the air washers just beyond. All dust and soluble impurities are removed from the air in passing through the air washers on the way to the heaters where the air is raised to the desired temperature. It is then blown by the fan into the plenum chamber.

The flues which carry the heated air from the plenum chamber to the rooms above are built into the walls of the building where indicated on the drawing. Each of these flues is provided with an individual damper at the base.

The air from the flues is admitted to the rooms through registers in the walls located about 8 feet from the floor while the vitiated air leaves through vent registers and is removed by Sturtevant steel plate exhausters. The positive supply and exhaust provided by this arrangement ensures the best possible ventilation, while the building at the same time is heated by the same warm air.

In the centre of the building on each side will be noted supplementary galvanized steel ducts leading to registers which heat the vestibules. Extra heating surface in the form of steam coils placed at the entrances of these pipes is provided, as these registers, although requiring the warmest air because they heat the easily cooled vestibules, are farthest from the fans and heaters.

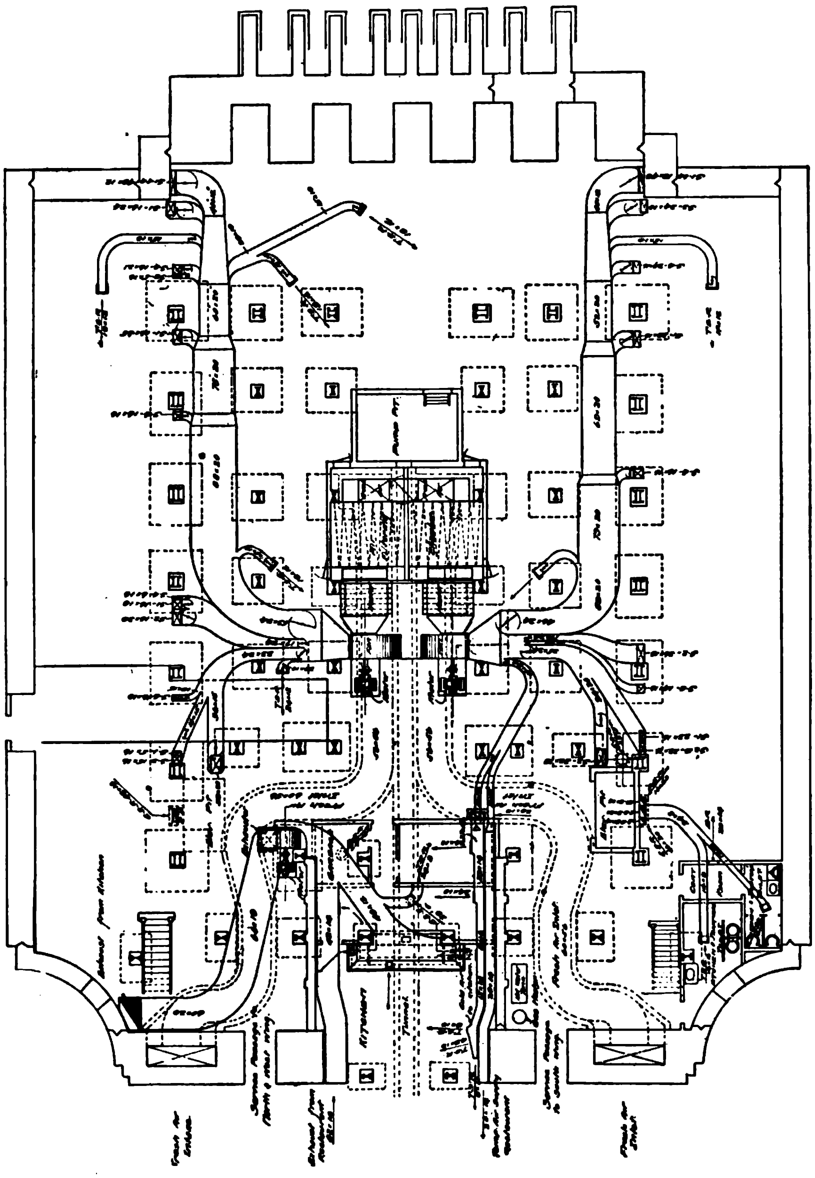

FIG. 91. EAST WING, WISCONSIN STATE CAPITOL.

198. East Wing, Wisconsin State Capitol

Another galvanized steel arrangement of heating ducts is found in Fig. 91, which shows a plan view of the basement of the East Wing of the Wisconsin State Capitol, Madison, Wis. Other parts of the building are heated and ventilated by the Sturtevant System, only one wing being shown here.

The two supply apparatus are situated in the centre of the building and as there is no open court in their vicinity, the fresh air is brought from the roof through a vertical flue in the walls of the building and is carried to the fans through two underground concrete ducts that are indicated in the drawing. The air is filtered by passing through an air filter and then enters the heater where it is raised to the desired temperature. The ducts are rectangular in cross-section and are suspended from the basement ceiling. It will be noticed that these ducts are provided with a damper at each end for regulating the amount of air supplied to the rooms above.

An exhaust apparatus, situated in the basement, exhausts the foul air from the restaurant and smoke, steam and odors from the kitchen. The fan blows into a large galvanized steel duct leading to a vertical flue which carries the exhausted air to the roof. This fan exhausts 54,000 cubic feet of air per minute.

199. Bailey Realty Company

On the previous pages the application of the Sturtevant System to large public buildings was discussed and the complicated nature of the distributing system showed that engineering talent of the highest degree is necessary to undertake the installation of a system in this class of buildings. The modern mercantile and office building also presents a serious problem to the designer of a heating and ventilation system.

In Fig. 92 is shown the basement plan of the mercantile and office building of the Bailey Realty Company, Cleveland, Ohio.

The ground floor and basement of this building are occupied by the Higbee Store, and it is this store that is heated and ventilated by the Sturtevant System. There will also be noticed an elevation drawing of the apparatus itself.

The air is drawn into the building through a vertical fresh

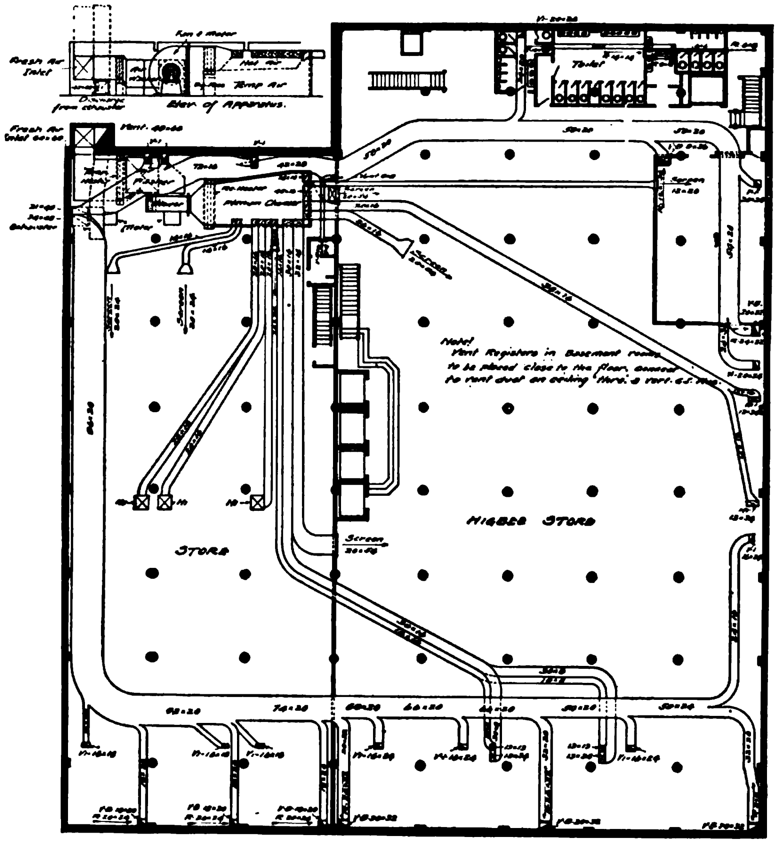

Fig. 92. Higbee Store, Bailey Realty Company, Cleveland, O.

air shaft running directly to the roof and passes through a tempering coil and air washer. Entering the fan, the air is blown through a heater or a by-pass beneath it into a double plenum chamber, the upper part of which contains warm air and the lower part tempered air. From this plenum chamber, the air is conveyed in rectangular ducts suspended from the basement ceiling to the various outlets and flues which supply air to both basement and first floor.

Another system of ducts conveys the vitiated air to an exhaust fan which expels it through a vertical exhaust shaft running to the roof. These ducts are of galvanized steel, are rectangular in cross-section and are suspended from the ceiling in the same manner as the supply ducts. The vent registers are placed near the floor, galvanized steel flues being used for connection with the ducts.

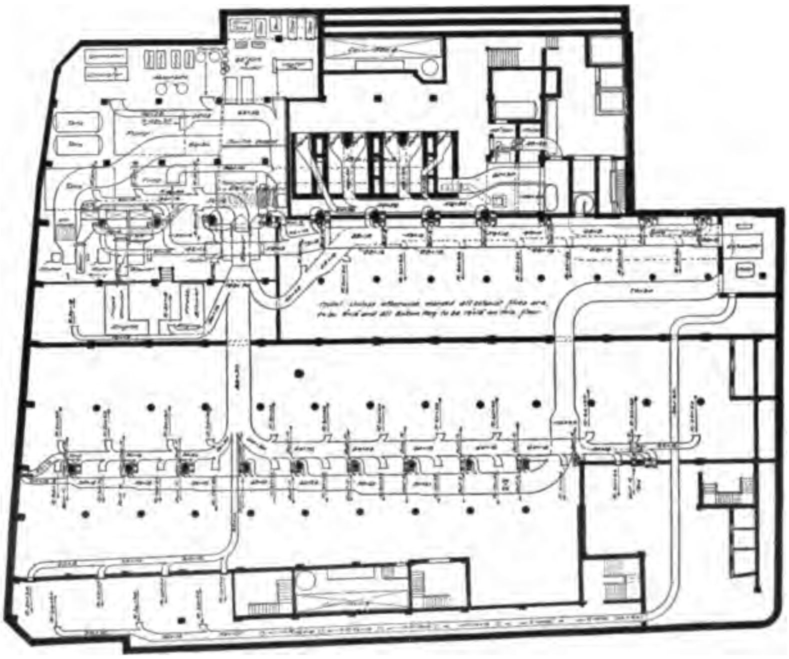

FIG. 93. HENRY SIEGEL COMPANY, BOSTON, MASS.

The offices in the upper floors of the building are heated by direct radiation, no provision being made for mechanical ventilation. The toilets, however, not being provided with exterior windows, are ventilated by means of a Sturtevant fan which exhausts 7,600 cubic feet of air per minute.

200. Siegel's Store, Boston, Mass.

An arrangement similar to that described in the previous section for heating and ventilating the Higbee Store, was followed in the installation of the Sturtevant System in Henry Siegel's store, Boston, Mass. The system here is more extensive, owing to its greater size, and has many interesting features in connection with its mechanical equipment. The building itself is seven stories in height, and is ventilated by the Sturtevant System. The heating is by means of direct radiation.

The large floor areas in a building of this type practically exclude all possibility of ventilation by natural means, making the installation of the Sturtevant System necessary. For this reason, both supply and exhaust apparatus are provided, insuring a fresh, clean atmosphere and the removal of all stale and vitiated air. The plan view of the basement, indicating the location of the apparatus and the layout of the heating ducts, is shown in Fig. 93.

As noted in the plan of the basement, there are six boilers provided with forced draft equipment. The air used by this fan is drawn from the pump and engine room, thereby also supplying ventilation and performing a double duty. The ventilating ducts are noted on the drawing. For ventilating the boiler room, a 48-inch disc fan, blowing into a duct leading to the main vent flue, is used.

The apparatus supplying air to other parts of the building are located in the basement as indicated on the drawing. Apparatus No. 1 is used to supply heated air to the seven vestibules on the first floor. The air is drawn through a heating coil before being blown into the air duct. Heating the vestibules by this method, a slight excess of pressure is easily maintained, so that all leakage, occasioned by the opening doors, is outward, and there is no tendency for cold air to rush into the building. This is a feature which makes the Sturtevant System particularly desirable in this instance.

The first floor is heated by Apparatus No. 2. The air, heated by passing over a Sturtevant steam pipe coil heater, is blown into galvanized steel ducts which convey it to the outlet registers.

Apparatus No. 3 supplies air to the basement and sub-basement. The heated air is blown into the duct system shown in the drawing and is admitted to the basement through registers and diffusers. The piping is rectangular in cross-section and is suspended from the sub-basement ceiling.

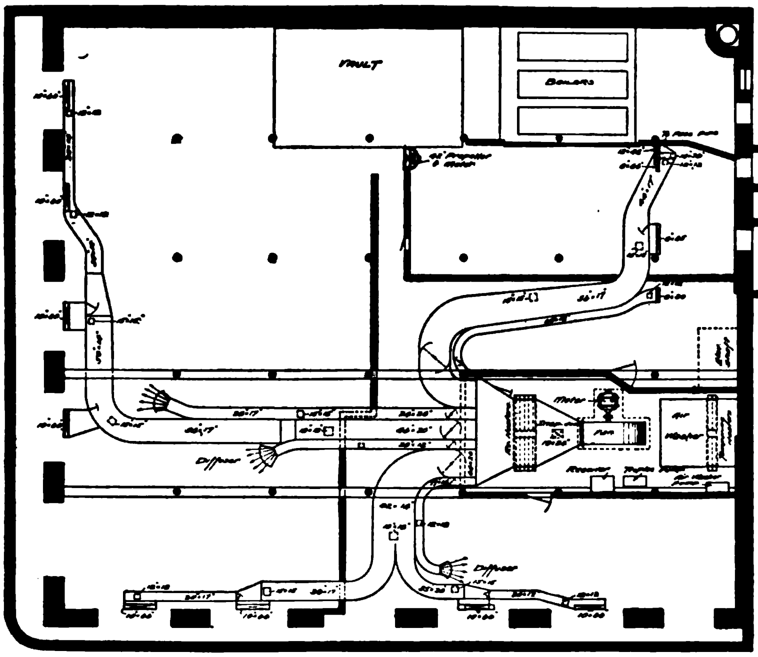

Fig. 94. Mechanics American National Bank, St. Louis, Mo.

For exhausting the foul air from the basement and sub-basement, an exhaust apparatus No. 4 is employed. This exhauster draws the air through galvanized steel piping, rectangular in cross-section and suspended from the sub-basement ceiling and blows it into the main vent flue. Vent registers opening into the exhaust duct are placed in the basement and sub-basement.

For exhausting from the toilets, vertical flues are provided which run to the roof of the building, where an exhauster, located in a pent house on the roof, discharges the foul air to the outside atmosphere. The air from the kitchen, laundry and lunch rooms and from several rooms on the fifth and sixth floors is removed by a steel plate exhauster also located on the roof.

201. Mechanics American National Bank

The Sturtevant System as applied to a combination office and bank building is shown in the plan of the basement of the Mechanics American National Bank, St. Louis, Mo., in Fig. 94. Here the entire building is heated by the Sturtevant hot blast system. This building is six stories in height, the ground floor being used for banking rooms and the upper floors for offices. The system provides warm, washed air to all offices through flues in the walls of the building.

The air enters the basement through tempering coils placed at one end of an air washer and is drawn by the fan through the washer into a closed room. The fan, motor and heaters are in this room, which is closed to prevent the entrance of air through any except the proper openings. The motor-driven fan blows the tempered and washed air through a Sturtevant pipe coil steam heater into a small plenum chamber from which large galvanized steel ducts convey the air to the flues. These ducts are rectangular in cross-section, are suspended from the basement ceiling, and are provided with dampers for regulating the flow of air to the flue. The flues are entirely concealed in the walls and are placed as indicated on the drawing.

In the offices, the air is admitted through wall registers communicating directly to the flues at a height of about 8 feet from the floor, while in the bank, the registers are placed in the floor. The vitiated air is removed by means of vent flues running to the roof and discharging out-of-doors.

202. Century Theatre, New York City

In its application to theatres, the Sturtevant System finds one of its most appropriate uses and involves the most elaborate and complete installation of apparatus and piping. The peculiar problems presenting themselves in this type of building have already been discussed in another place. The successful solutions of these problems in two New York theatres are indicated here.

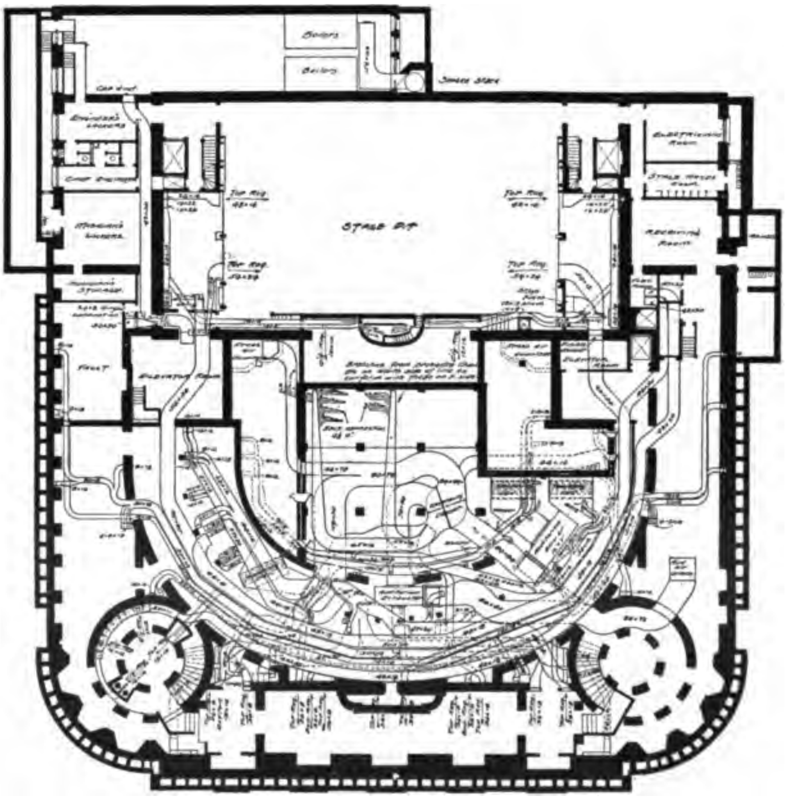

FIG. 95. CENTURY THEATRE, NEW YORK CITY.

The Century Theatre, situated at 62d and 63d Streets, Central Park West, New York City, is one of New York's largest and finest theatres. The plan view of the basement, showing the location of the ventilating apparatus and the various ducts, is given in Fig. 95. Direct radiation is used for heating the building, but a most thorough mechanical ventilation system is used, as can be seen in the drawing. Galvanized steel piping suspended from the basement ceiling is used. The air is moved at low velocity, because the construction and arrangement of the building and the large amount of piping used necessitates many turns. The apparatus is, moreover, completely reversible, the reversing damper, noted on the drawing, making this possible. This is a feature which is quite desirable in a theatre, as the ability to reverse the currents of air as they pass through the theatre auditorium gives great flexibility to the ventilation system.

The main auditorium blower receives air from outside by way of a vertical vent shaft running to the roof and built beside the elevator shaft which is located at the right of the stage pit. The auditorium is provided with openings in floor, walls and ceiling through which air may either be admitted or exhausted. By means of the reversing damper, the air may be supplied through the floor and removed through the ceiling or supplied through the ceiling and removed through the floor as desired. As shown in the drawing, the reversing damper opens the duct which supplies air to the auditorium from above and permits the auditorium exhauster to draw out the air through the floor outlets, discharging it into the auditorium air up-take which is a vent flue running to the roof. Two other systems of piping provide for the supply and removal of air from the corridors.

With the damper reversed, the auditorium blower supplies air through the floor outlets and the auditorium exhauster removes the vitiated air. The functions of the ducts supplying and removing air from the foyer and corridors are also reversible, the supply ducts becoming exhaust ducts, and *vice versa.*

The stage and stage boxes are supplied with air by the stage blower through galvanized steel piping. Toilets are ventilated by a separate system, so that there is no chance of interchange of air between these and other rooms.

203. The Little Theatre

In striking contrast to the Century Theatre is the Little Theatre, also in New York, and probably one of the smallest theatres in the country, as it is provided with only 283 seats. The theatre auditorium has no exposed walls or ceiling area, so that heat losses are slight and the problem is one of cooling rather than of heating the theatre. Ventilation is absolutely necessary, as the auditorium is practically hermetically sealed during a performance.

The fresh air is brought into the building through a vertical air shaft, crosses it by way of a rectangular galvanized steel duct suspended from the basement ceiling and enters the tempering coil. Here it is heated to about 65 degrees. The fan blows the air into a plenum chamber which occupies the entire space below the auditorium floor and from this the air enters the auditorium through floor outlets placed under every seat. Rising as it becomes warmed, the air leaves the theatre, which has no galleries or balconies, through the perforated ceiling, the entire space above the auditorium being used as an exhaust chamber.

Two toilets and a lounging and smoking room in the basement, are ventilated by means of a duct connected to the ventilating flue and through which the air is exhausted. A Ready-to-Run Ventilating Set in the ladies' room furnishes the necessary ventilation.

204. Steamships " St. Louis " and " St. Paul "

These twin transatlantic liners of the American Line are heated and ventilated entirely by Sturtevant apparatus, all other means of heating having been discarded and the Sturtevant System adopted throughout. The system provides both for the supply of fresh air and the removal of vitiated air. Practically all parts of the ship being ventilated, a perfect circulation of air is assured by using both supply and exhaust fans.

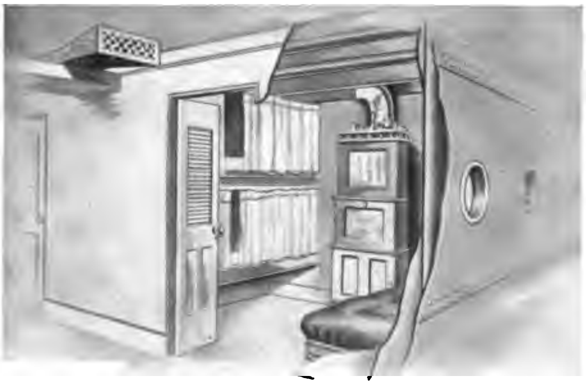

FIG. 96. CABIN VENTILATION.

The heaters are used in connection with the supply fan. The presence of water tight bulkheads prevents the extension of air pipes horizontally through the lower decks. Four separate apparatus were therefore introduced, each consisting of supply and exhaust fans, both located upon the shade deck and driven by direct connected electric motors. From each of these apparatus, pipes extend downward and are connected with systems of horizontal ducts upon each deck, no pipes passing through the bulkheads. Small auxiliary fans, one on either side of the ship, supply fresh cool air directly to the engine rooms while a large fan is devoted solely to exhausting from the galley.

The pipes are carried close up to the deck beams above. On the berth deck, the supply ducts are extended down each of the stateroom alcoves, discharging air overhead toward the side of the ship, as indicated in Fig. 96. Positive circulation throughout the stateroom is accomplished by extending an exhaust pipe down behind the commode and dressing case, as shown, and providing it at the bottom with a suitable opening into the corridors. The latticed panel permits of the ready passage of air.

CHAPTER X

STURTEVANT APPARATUS

205. Selection of the Apparatus

IN the following pages are described, in as brief a manner as possible, the apparatus used in connection with the Sturtevant System of heating and ventilation. Special catalogs covering all of this apparatus and describing it more thoroughly are published by the Company.

The essential elements of the apparatus are the fan and its casing, the motor or engine driving the fan, the heater and the condensed steam apparatus. This Company builds fans in several types to cover all requirements for ventilation and heating work. Upon the proper selection and best combination of fan, motive power and heater depends to a large extent the effectiveness and economy of the system.

The capacity of a fan is evidently measured by the number of cubic feet of air it can deliver per unit of time at a stated speed. The efficiency of the type of fan, therefore, enters as a determining factor in deciding upon its size. In any extended system of heating and ventilating of which the fan is an element, it is necessary that the peripheral type of discharge should be adopted in order to overcome the existing resistance of ducts and flues. The disc or propeller type, which forces the air in lines parallel to its shaft, is very inefficient where such resistance exists; but a fan wheel, either cased or open and delivering the air at its periphery in a more or less radial direction, is capable of meeting all requirements. It is evident that the primary factors entering to determine the capacity of a fan of a given type, are its size and the speed at which it is

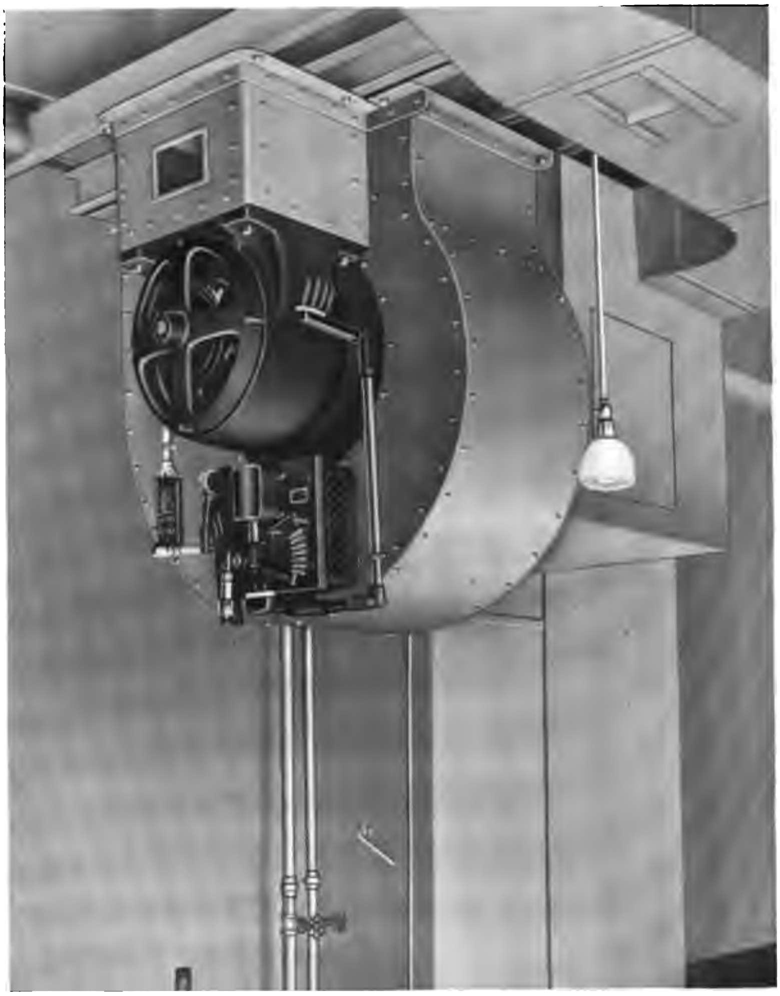

FIG. 97. STURTEVANT FAN AND MOTOR SUSPENDED FROM GARAGE CEILING, UNITED GAS IMPROVEMENT CO., PHILADELPHIA, PA.

driven. The volume of air delivered by a fan practically varies directly with the speed, while the air pressure created changes in proportion to the square of the number of revolutions and the power required to drive the fan varies in the ratio of the cube of the speed. That is to say, doubling the speed of the fan doubles the volume delivered (which is the measure of its capacity), increases the air pressure created to four times that previously existing while the power required rises to eight times that at the original speed.

These facts should be clearly borne in mind in the selection of a fan. So far as circumstances will permit, a large fan operating at moderate speed should be chosen as a means not only of decreasing the power required but of also reducing the losses due to excessive friction in the ducts incident to the movement of air at high pressure. For factory and mill work the fan may approach nearer the minimum size, for higher air velocities are not only permissible but frequently desirable to force the air long distances, while the usual presence of an experienced engineer ensures more frequent attention where the fan is constantly operated at high speed. In the schoolhouse, the theatre, the church and similar structures, where only low velocity currents are permissible, the fan should be of the maximum size and capable of delivering the required volume of air at the least practicable speed.

To summarize, it is necessary in the selection of a fan to determine: first, its required capacity; second, the type to be adopted; and third, the size best adapted to the given requirements as largely influenced by the maximum speed allowable. Such selection cannot be based alone upon published tables of fan capacities, for even with the type of fan clearly defined, there is opportunity for disastrous mistakes in deciding upon speed and in making the allowances that are necessary for the loss in volume moved, due to the resistance encountered in passing through the heater and through the distributing ducts. The tendency, from a commercial standpoint, is strongly toward the selection of too small a fan, and to this fact is due the failure of many of the earlier plants installed under the specifications of those who possessed but limited experience in these matters. Therefore, the selection of the type of fan and the determination of its size should be left to parties fully qualified to decide upon this important factor in the heating and ventilating problem.

206. Multivane Fans

The Sturtevant Multivane fan, the most efficient commercial fan in the world, is widely used in heating and ventilating work and possesses some advantages not found in the steel plate fan which, heretofore, has been used so generally. Aside from greater efficiency, the Multivane fan has the advantage of requiring less space than the steel plate fan. In places where large volume fans are necessary and where space is limited, the Multivane can be used to decided advantage. The high speeds at which these fans may be run permit of the use of electric motors and steam turbines as well as high speed engines for direct connected drive.

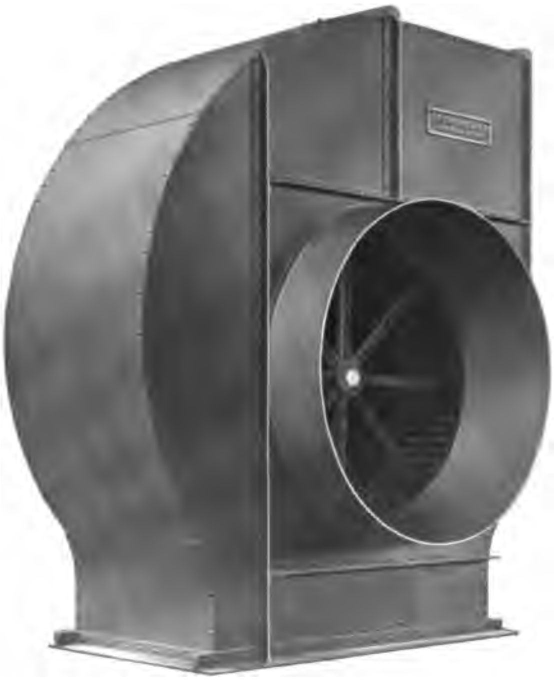

FIG. 98. FULL HOUSING STURTEVANT MULTIVANE FAN (EXHAUSTER).

The fan wheel of the Multivane fan is in a distinct departure from that of the steel plate. The blades are long and narrow, curved radially, and contain cup-shaped depressions which increase the efficiency of the wheel and prevent the slippage of air along their surfaces. These blades are riveted to annular steel plates and to the tips of T shaped steel arms in a manner shown in Fig. 100. The narrow blades permit of a large inlet, cutting down the resistance at this point.

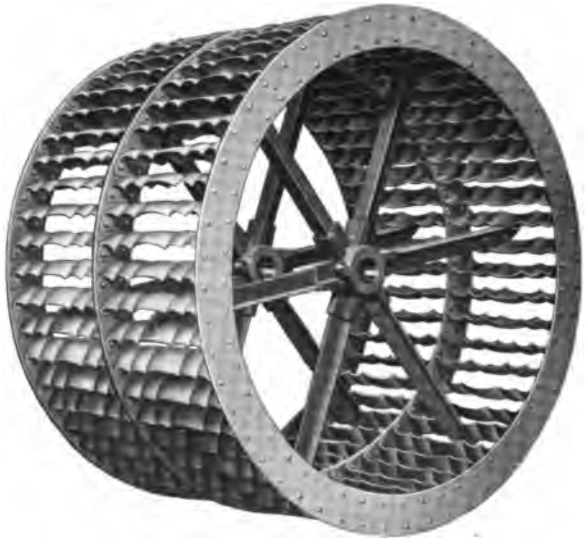

Fig. 99. Fan Wheel, Multivane Type.

The hub and driving arms, or the spider, as it is called, consist of T shaped steel arms cast-welded into the hub and are riveted to extra heavy fan blades at the outer end. In larger fans, two or more spiders are used. This construction is especially strong and rigid and being perfectly balanced, high speeds are practicable.

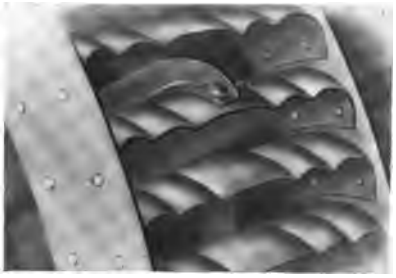

Fig. 100. Method of Riveting.

The scroll of the housing is designed to give the highest efficiency without the vibration or noise found in other high speed fans. It is built of refined steel plate thoroughly braced with angle iron. Ball and socket journal boxes permit of self alignment of the shaft in all directions and of easy adjustment for wear. In the base of the box is an oil well of large capacity from which oil is abundantly fed to the bearing surface by oiling rings. The journal boxes are lined with Sturtevant white metal, a babbitt that has been used for years for high speed fans and engines.

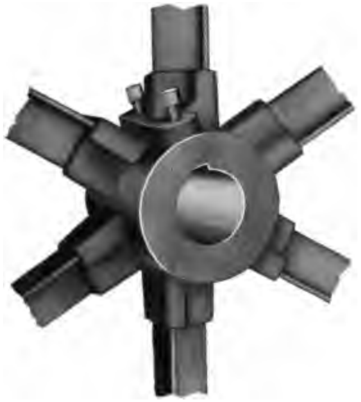

FIG. 101. HUB.

Multivane fans are made in either single or double width, the double width providing twice the volume with no greater expense of head room.

207. Steel Plate Fans

Steel plate fan wheels are made up of T shaped steel arms cast into iron hubs carrying the blades or floats, which, together with the side plates of the wheel, are

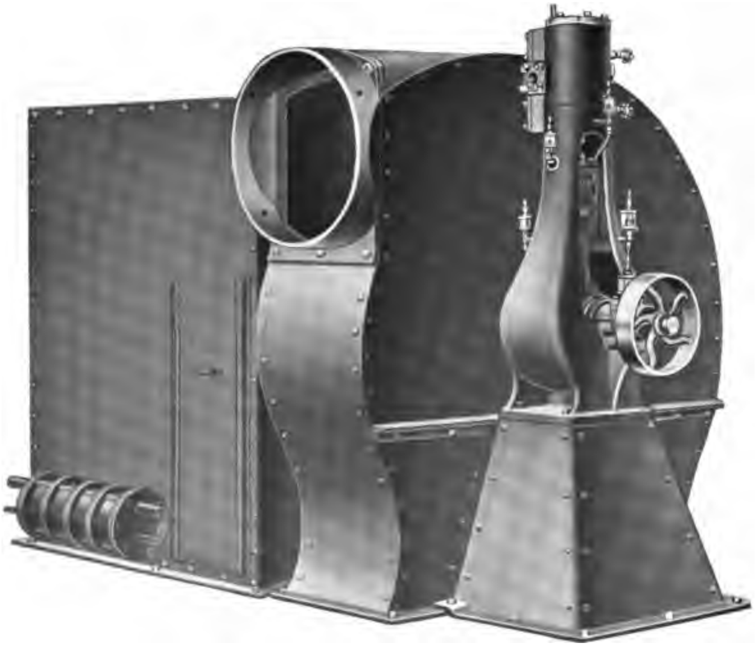

FIG. 102. STURTEVANT STEEL PLATE FAN, HEATER AND VS-1 ENGINE.

constructed of steel plate. For all sizes above the smaller, two sets of hub and arms, or spiders, as they are called, are used. This construction combines minumum weight with maximum strength and durability and is especially designed to meet the requirements of ventilating fans, namely, the ability to handle the largest volume of air at low pressure with a slight expenditure of power. The shafts are of steel, turned and ground to size, and are supported in Sturtevant patent, brush-oiling bearings. These bearings are so constructed that the oil is not brought into the fan by the suction. Having once filled the reservoir with oil, only infrequent attention is necessary. Steel plate fans are built for static pressures up to 4 inches of water and for volumes, limited only by the size of the apparatus. Steel plate fan wheels are encased in steel plate casings, which can be constructed for any discharge. These casings are built as exhausters or blowers.

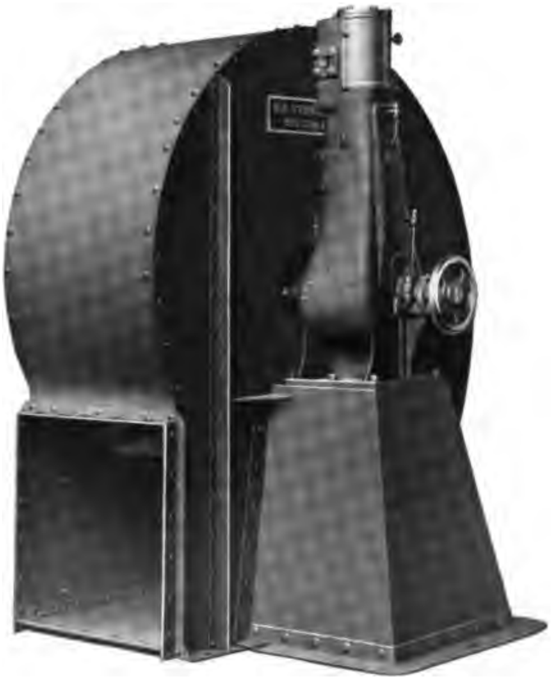

FIG. 103. STURTEVANT STEEL PLATE STEAM FAN.

Steel plate fans may be driven by belt, or direct connected to electric motors or steam engines. In case of a direct connected motor, or steam engine, a sub-base of steel plate and angle iron is frequently used as a foundation for the motor and the engine.

208. Steam Fans

As it is generally desirable that the drive of the fan be independent of the other sources of power throughout the building, the direct connected steam engine and fan are exceedingly popular, especially when the steam exhaust from the engine may be used in the heater. Sturtevant steam engines for driving the fans have been specially designed for this type of service and are furnished in direct connected units. The combination of fan and steam engine direct connected in this way is designated as a steam fan.

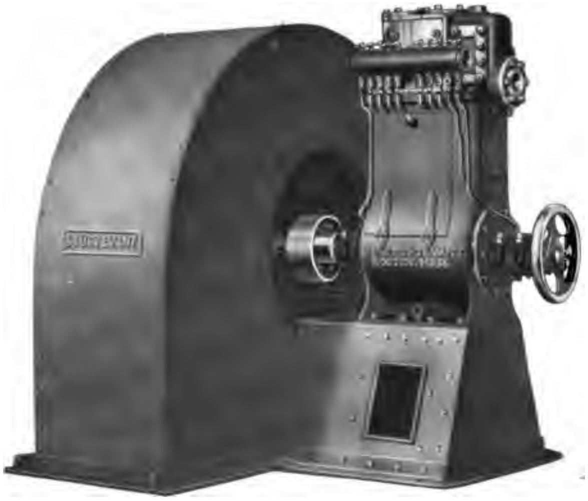

FIG. 104. STURTEVANT STEAM FAN, DOUBLE ENGINE.

The casing and wheel of the fan are identical with those used as pulley fans, but in place of the pulley there is provided a direct connected steam engine supported upon a base of steel plate and angle irons and carrying the fan wheel upon the end of its shaft, as indicated in Figs. 103, 104 and 105. Single or double cylinder, vertical steam engines are commonly employed in small sizes for ordinary work. For larger fans, the horizontal engine is employed. Steam fan engines are built for high or low pressure to accommodate the various pressures met with in heating plants.

209. Cone Fan

Wherever a fan wheel is to be used without casing and under conditions that require anything above the most moderate pressure, the cone fan is particularly desirable. As ordinarily installed, it is placed close up to a division wall in which is located an inlet opening concentric with the inlet of the wheel. The air is thus drawn from one side of the wall and delivered into a space of greater or lesser extent upon the other side, where the fan is located. As ordinarily constructed and located, the type of fan is clearly shown in Fig. 106. The base of this wheel is a conical iron casting with its apex toward the opening in the wall, so that the air entering the wheel is gradually deflected toward the numerous curved blades which extend outward from the conoid, and are so attached to the back as to make a very stiff machine. A bar across the inlet, and a trussed support in the back, carry the necessary journal boxes. Such a cone fan possesses marked advantages over a disc fan in that it will deliver air against resistance; also, back-lash is impossible and the centrifugal force of the blades is utilized. At a given peripheral speed the cone fan without a casing will give far superior results in volume of air moved and in proportional power expended. For certain conditions the wheel may be double, *i. e.*, with two inlets and conoids and connection made to both, or it may be enclosed in a steel plate housing in the

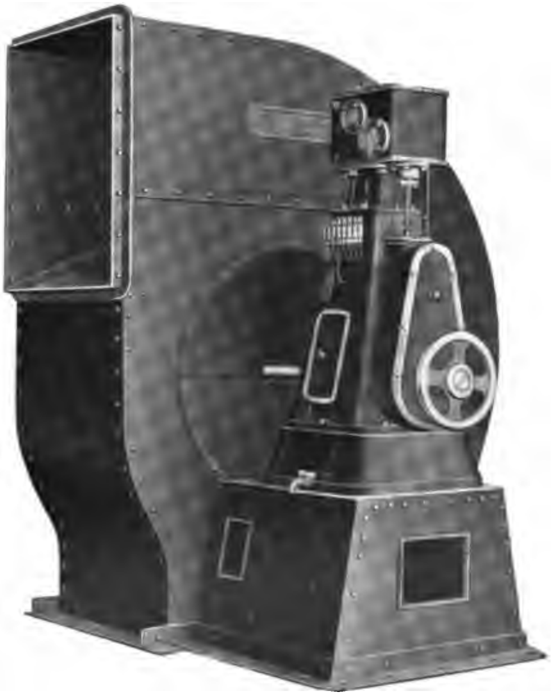

FIG. 105. STURTEVANT VS-7 ENGINE AND MULTIVANE FAN.

same manner as the regular fan wheels. When a sub-basement is to be kept filled with air under slight pressure, as in the plenum system, this fan is very economical and convenient, as no connecting ducts are required.

If desired, the wheel can be fitted with a direct connected engine or motor placed upon the back side of the wheel; or, if circumstances require it, the fan wheel may be arranged upon a vertical shaft.

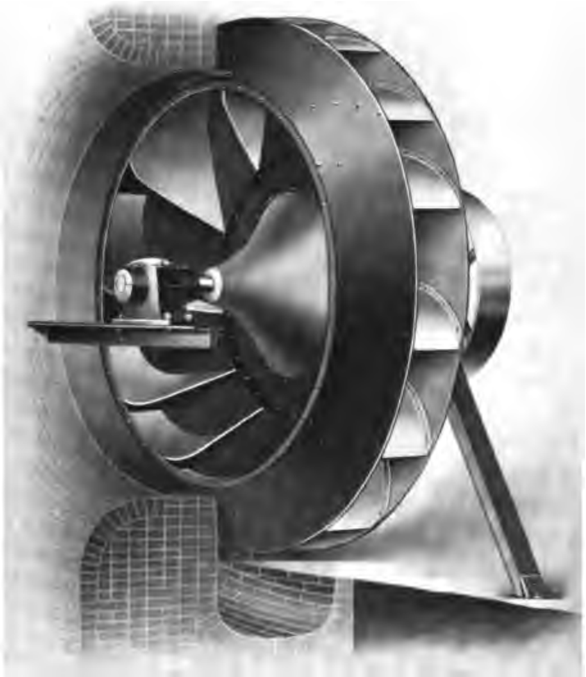

FIG. 106. STURTEVANT CONE FAN.

210. Propeller and Disc Fans

Propeller and disc fans are used for ventilation purposes when air is to be exhausted in large volumes at low velocities and against low resistances. They are used either to accelerate the movement of air in vent flues or to exhaust foul air, fumes, odors, steam or smoke from kitchens, club rooms, laundries and similar places. The blades of the disc fan are so set and those of the propeller fans are so formed as to move the air forward in a direction parallel to the axis of rotation of the fan.

Great discretion should always be exercised in the introduction of either type of fan under plenum conditions, for they lack the ability, except at excessive expenditure of power, to force air through an extended system of distributing ducts. When installed under proper conditions, and for the purposes for which they are introduced, these fans are most satisfactory and economical.

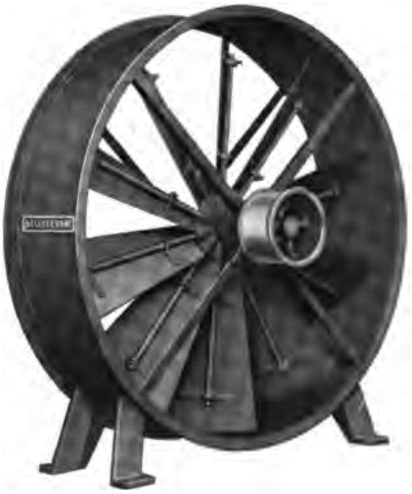

FIG. 107. STURTEVANT DISC FAN.

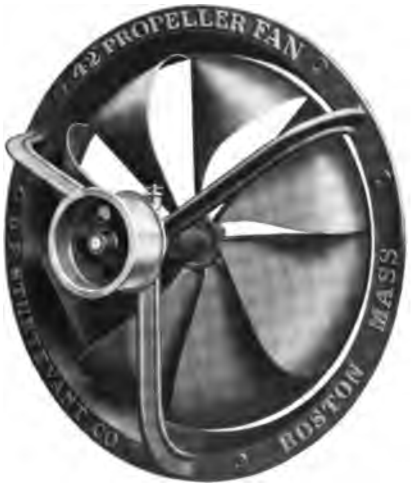

FIG. 108. STURTEVANT PULLEY PROPELLER FAN.

Propeller fans are made with direct connected electric motors in units that are self contained and are provided with wall rings by means of which they are fastened into the walls of buildings or the sash of a window. Electric operation permits of remote control through switch and rheostat in places that are otherwise inaccessible.

211. Monogram Fans

The most substantial form of enclosed exhaust fan is shown in Fig. 110. The shell is entirely of cast iron, the supporting hanger for the journal boxes being bolted thereto. Both bearings, which are of exceptional length and arranged for thorough oiling, are placed upon one side of the fan, leaving the inlet upon the other side entirely unobstructed for the entrance of air.

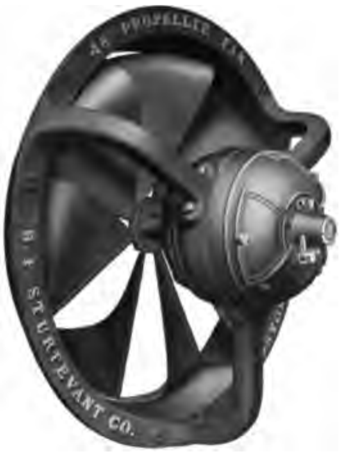

FIG. 109. STURTEVANT ELECTRIC PROPELLER FAN.

An exhauster obviously provides opportunity for the ready connection of its inlet to a system of piping, a very necessary feature in a ventilating plant. Monogram fans, so called from the monogram cast on the side, are regularly built with bottom horizontal discharge, as shown in Fig. 110. They are also constructed to discharge horizontally at the top, directly upward, or directly downward when occasion demands.

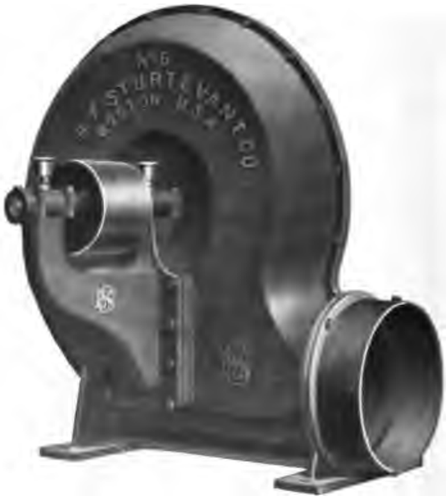

FIG. 110. STURTEVANT "MONOGRAM" EXHAUSTER.

The capacity of the Monogram fan is relatively small, even in the larger sizes, when compared with the capacity of some of the large steel plate fans. The former type is, however, extremely serviceable for the ventilation of small apartments, or for forcing or drawing air through long and comparatively small conduits where the resistance to be overcome enters as an important element. Under these circumstances, the particular value of this fan lies in the character of its design, for it may be run continuously and noiselessly at the high speed necessary to produce the requisite pressure.

Monogram exhausters are used for removing air from toilets, for ventilating kitchens and for handling gases and fumes. They can be made with casings of non-corrosive material and with wheels of copper if the nature of the fumes and gases handled necessitates this construction.

212. Ready-to-Run Ventilating Sets

Primarily designed for the United States Navy and used in places on shipboard where ventilation is not generally provided but where it often becomes necessary to supply fresh air for the comfort of workmen, the Ready-to-Run Ventilating Set has been placed upon the market recently for general sale and the great variety of uses to which it may be put has made it very popular. From the refreshing draft such as is supplied by an ordinary desk fan to the ventilation of small theatres and club-rooms, the little blower covers a wide field.

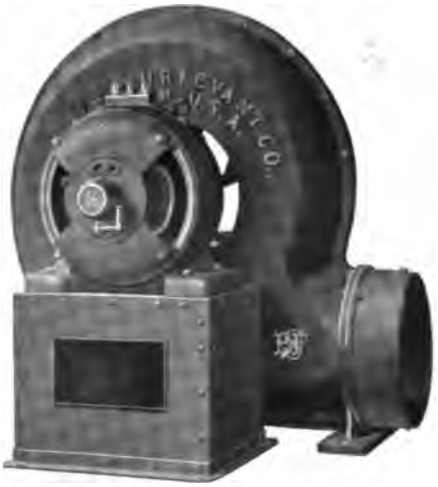

FIG. 111. STURTEVANT ELECTRIC "MONOGRAM" BLOWER.

Ready-to-Run Ventilating Sets are built in five sizes. With the exception of the largest, they may be carried from place to place and operated from a lamp socket. A special starting switch is necessary for the largest set.

The outfit consists of motor, fan and casing, all self-contained and ready to run. Fan and motor are on the same shaft, while the fan casing, which has but one inlet, is rigidly fastened to the motor frame. The outlet of this casing may be turned so as to discharge in any direction.

The fan wheel is of the Sturtevant Multivane design and is carefully balanced for vibrationless operation. The construction is strong and rigid and large volumes of air are handled at a slight expenditure of power.

The casing is in two sections, split vertically, and is made of pressed steel. Inlets and outlets are arranged for receiving exhaust and discharge pipes when it is desired to use the fan in connection with a system of piping.

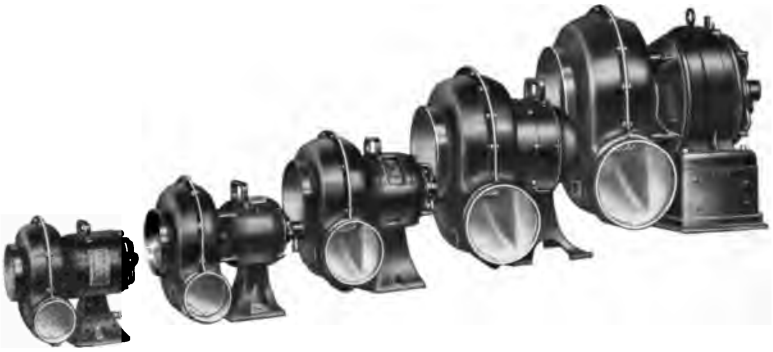

FIG. 112. FIVE SIZES OF STURTEVANT READY-TO-RUN VENTILATING SETS.

The advantage of the Ready-to-Run Ventilating Set over the ordinary desk fan lies chiefly in the fact that while the latter will create a movement of air, the former can be used as a means for providing positive ventilation. The foul air of an apartment may be discharged out-of-doors or fresh outdoor air may be blown into the room as is most desired.

For ventilation purposes, these little blowers supply a field that has, up to the present time, been poorly served. Places too small to warrant the expense of a ventilating apparatus or that require only the occasional use of such apparatus have heretofore depended upon natural and inadequate means for ventilation. The Ready-to-Run Set makes possible the ventilation of all small rooms by this simple and economical means.

There are certain applications of the Sturtevant Ready-to-Run Ventilating Set that are unique in themselves and that offer a most satisfactory solution to puzzling ventilation problems. The Company has made special study of the conditions affecting the application of Ready-to-Run Sets and has designed systems for various uses. A few of the more important have been mentioned already.

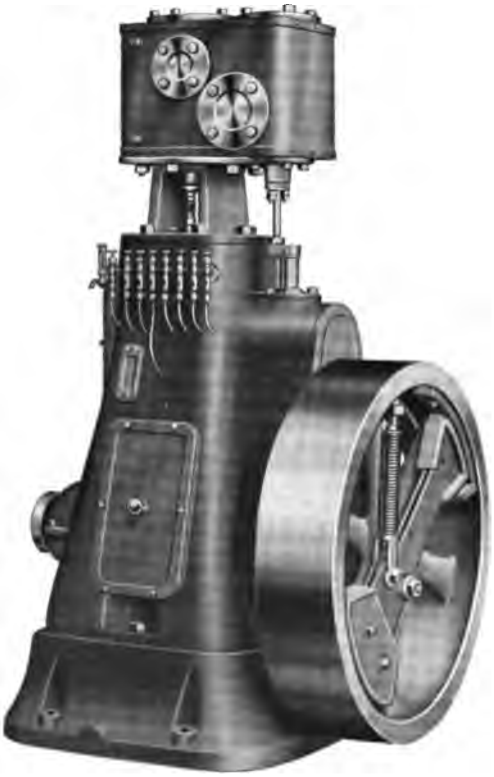
Fig. 113. Sturtevant VS-7 Engine.

213. VS-7 and Vs-8 Engines

Fifty years of experience in the design and construction of steam engines for high class fan drive have brought about the Sturtevant vertical engine of the classes VS-7 and VS-8. These engines represent the finest in vertical steam engine construction and will give continuous satisfaction under all operating conditions.

The VS-7 and VS-8 are compact and quiet running engines, and may be operated continuously for long periods, requiring but little attention. They run with practically no vibration, and the mechanical efficiency is exceptionally high. They are entirely enclosed and self-contained and because of the large diameter and the short stroke, develop great power at high speed without excessive piston travel.

The reciprocating parts are entirely enclosed within a frame provided with large openings placed in just the right positions to secure ready access to all parts subject to wear, the openings being provided with covers that make the frame oil and dust proof. In the top of the frame of the VS–7 engine is cast a large reservoir into which a simple and durable pump, located in the base, pumps the oil from a reservoir in the base to the upper. Flowing by gravity, the oil is conveyed to the various bearings requiring lubrication through pipes of brass. Between cylinder and frame is a distance piece, within which are enclosed a water shed partition and stuffing box. The VS–8 engine is similar to the VS–7, but is provided with forced lubrication.

These engines can be supplied for either automatic or throttling control and for steam pressures from 15 to 200 pounds and over. They may be either direct or belt-connected to fans.

214. HC–1 Engines

Where steam is available the steam engine is a most satisfactory source of power for fan propulsion, as the exhaust steam may be utilized in the heater and the motive power thus obtained at practically no cost. For schools, libraries, public and municipal buildings, hospitals and similar institutions, theatres, churches and office buildings, the Sturtevant horizontal centre-crank engine of what is known as the HC–1 type provides a drive that is silent, economical, enduring and flexible. Built especially for this service, it possesses features that distinguish it from other and cheaper engines built for similar purposes.

HC–1 engines may be furnished for either automatic or throttling governor control, for high, medium and low steam pressure and are capable of continuous operation for long periods with but little attention. For much public building work, where steam pressures are low, low pressure engines are furnished having the same frames, but larger cylinders. HC–1 engines are built for pressures as low as 15 pounds and as high as 200 pounds.

The engine frames are equipped with openings to give ready access to the interior, having oil and dust proof covers which are easily removable. The frame is fastened to an especially heavy cast iron base which can be securely anchored to foundations. Cylinders and valve chests are cast together of close-grained iron, thoroughly insulated with magnesia and covered with planished steel. Cylinders are equipped with relief valves and are tapped for indicator connections and plugged.

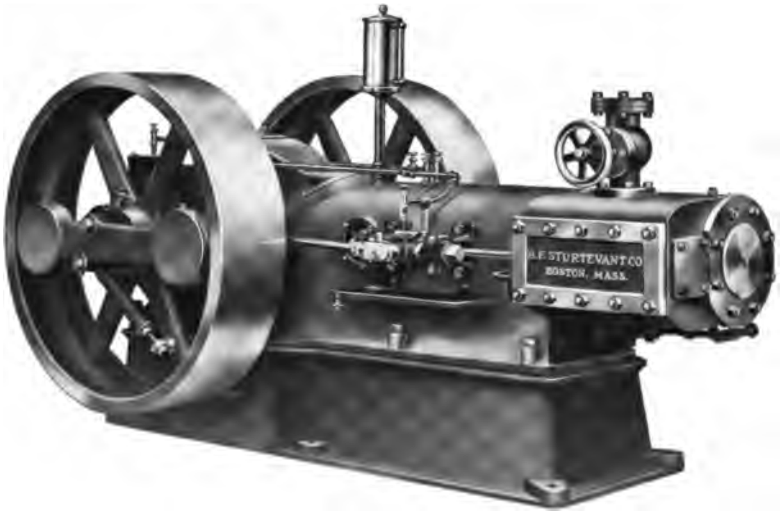

FIG. 114. STURTEVANT HC-1 ENGINE.

A water-shed partition between cylinder and frame, fitted with a stuffing box, prevents water from entering the cylinder. The valves, of the balanced piston type, are in removable bushings.

All bearings are lined with Sturtevant white metal, hammered in, bored and scraped to fit. The main bearings consist of two parts, the lower half being a shell that is easily removed, and the upper half a cap adjustable by means of wedges. The crankshaft is of open hearth steel in a single forging and the connecting rod is of forged steel.

The throttling engines are not regularly furnished with a throttling governor, but any of the standard makes may be supplied if desired. The automatic engines are supplied with a Rites inertia governor, the mechanism of which is located in the heavy fly wheel.

Lubricating oil is contained in an elevated tank of large capacity, fitted with gauge glass, and from which the oil is conveyed by piping to all bearings. With the exception of the cross-head and crank pins, the oil is delivered directly to the bearings from the pipe, but in the case of the former, it is delivered to a bronze cup so constructed that it is always in a position to catch the drip oil. In the case of the crank pin, the oil is delivered by centrifugal force through a hole in the crank webs and crank pin into the crank pin box.

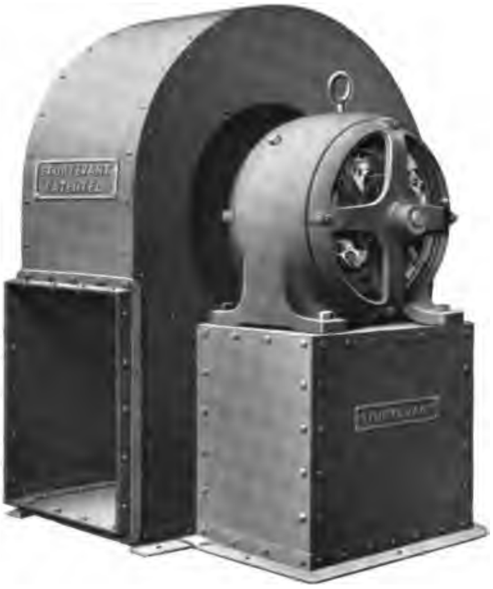

Fig. 115. Sturtevant Electric Fan.

Horizontal centre-crank engines may be either direct or belt-connected to fans, as circumstances require. The great number of these engines in satisfactory service today bears witness to the increasing popularity of this type of drive.

215. Electric Motor Drive

For public building work, for schools, churches, government and municipal buildings, the electric drive offers advantages that make it very popular. Where steam is not used for purposes other than heating, a regular heating boiler is sufficient to supply steam to the Sturtevant heater, while an electric motor may be used for driving the fan. When fans are run in summer for ventilation or cooling, an electric motor drive obviates the necessity of operating a steam boiler. In cities where steam is supplied from central stations by public service corporations, the motor makes a more convenient drive. When fans are used independently of heaters for ventilating purposes, the motor drive is ideal. It is obviously easier to carry electric wiring than steam piping, and the motor is more easily controlled from a remote source than the steam engine, a fact that many times influences the engineer in selecting the proper form of drive for his fans.

216. Sturtevant Electric Motors

Direct current, Sturtevant electric motors are built especially for driving blowers and exhausters, either direct connected or by means of belt or chain. They are of the open, semi-enclosed or enclosed type, according to requirements. Enclosed motors will not deliver as much power as the same sized machine of the open motor type, because of overheating due to lack of ventilation. The enclosed motor has the advantage of being moisture and dust proof, and is used where conditions demand a thoroughly protected motor.

217. Type " H " Motors

Type " H " motors are made in sizes up to 35 horsepower for fan drive, and are open, semi-enclosed or enclosed, according to conditions. Without destructive sparking or heating, these motors will carry a 25 per cent. overload, for two hours with a maximum temperature rise of 50 degrees centigrade. The magnet frame and bearing brackets are of cast iron, the latter being of skeleton construction and fastened to the magnet frame by four bolts equally spaced so that the motor may be bolted to the floor, wall or ceiling without additional change.

The pole pieces are through-bolted and located off-centre to permit the use of duplicate bearing brackets on either end. They are built of soft steel punchings, secured between end plates while under pressure. Field coils are carefully insulated by heavy tape, and are machine wound. The armature of the iron-clad, slotted drum type, is built up of soft steel punchings, each insulated by a coating of japan. These laminations are assembled on a cast iron sleeve which is provided with openings for free circulation of air. The coils are double covered copper wire or strap, held in the slots by fibre wedges. The commutator and armature make a self-contained unit. The commutator is built up of bars of hard drawn copper, securely held in a cast iron shell of spider construction with the best amber mica for insulation between the segments. Great care being exercised to select mica of the same hardness as the copper, the wear of the two substances is uniform. The commutator is assembled, while hot, under great pressure which holds each bar firmly in place and reduces the liability of its wearing loose. The commutator bars are provided with risers into which are soldered the leads from armature coils. The carbon

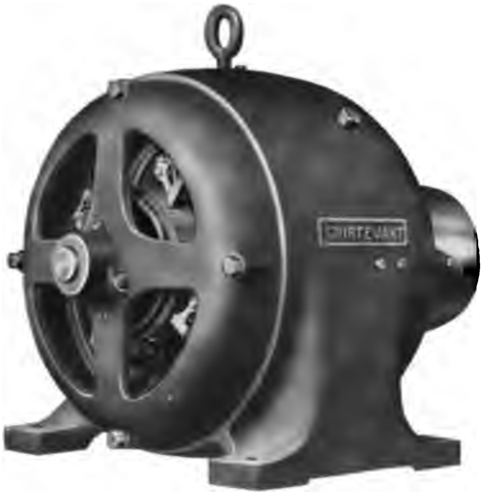

FIG. 116. STURTEVANT TYPE "H" MOTOR.

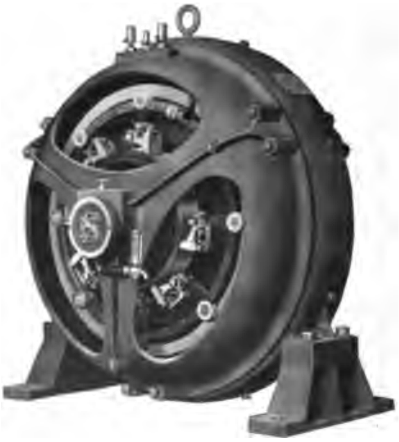

FIG. 117. STURTEVANT 8 POLE MOTOR.

brushes are held in brush holders of the sliding socket type, which are supported by a ring of spider construction, which in turn is supported in a machined recess in the magnet frame. The front bearing bracket clamps it firmly in place, although it may be easily shifted if desired. Type "H" motors are furnished for standard voltages.

218. Eight Pole Motors

Eight pole motors are of lower rotative speed, and are well suited for direct connection to large fans. For driving small exhausters of the fan type, the motor may be mounted on a special annular plate (see Fig. 118) which is bolted to the side plates of the fan, the fan wheel being overhung on the end of the motor shaft. Larger motors are mounted on suitable bases. They are capable of carrying 50 per cent. overload momentarily without shifting brushes or destructive sparking and of continuous operation at 25 per cent. overload, without overheating or sparking. The smaller sizes are entirely enclosed by attaching three plates to the end casings which are machined to fit a ring frame. Bearings of the ring oiling, self-aligning type are formed in the end casings. For the larger sizes, there are no end casings, the shaft being supported in journals in pedestals which, with the magnet frame, are bolted to a substantial base forming an extremely rigid foundation (see Fig. 119). The pole pieces are through-bolted to the magnet frame with

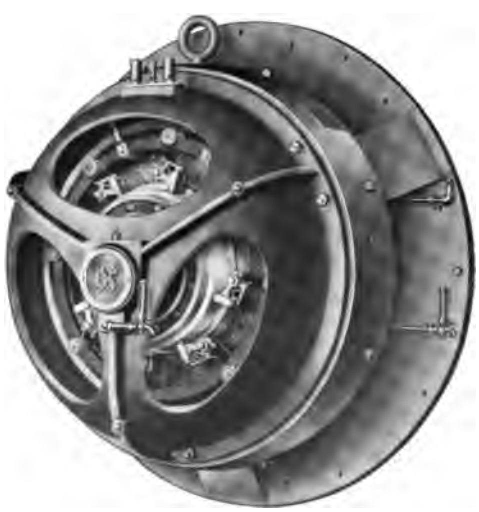

FIG. 118. STURTEVANT 8 POLE MOTOR.

cast iron shoes on the inner extremities. Each pole piece is of wrought iron, energized by its own field coil, which is of the best double covered copper wire, machine wound and thoroughly insulated and water proofed. The armature is of the slotted drum type made of punchings of steel properly insulated and clamped on the cast iron spider or hub. The armature is well ventilated. For very low speed and high voltage, the armatures are wire-wound, while bar winding is used for all other conditions. Armature field coils are made water and oil proof by dipping in armalac and baking for 24 hours. The commutator is made up of segments of hard drawn copper insulated with carefully selected mica so that the wear of both substances is uniform. The segments are secured to the cast iron shell, clamped by a steel ring. The brushes are of carbon, and are held in brush holders of the sliding socket shunt type. They are mounted on a brush ring which may be completely rotated around the commutator. Eight pole motors are made for standard voltages.

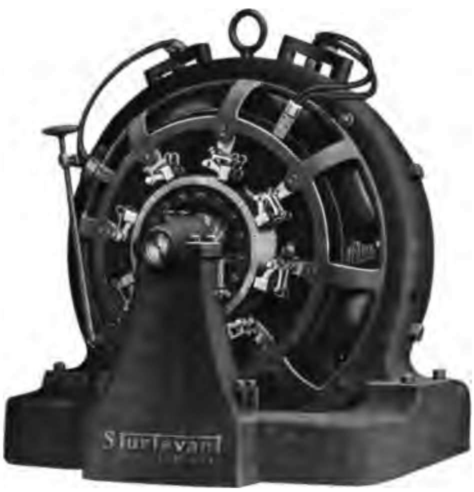

FIG. 119. STURTEVANT 8 POLE MOTOR, PEDESTAL TYPE.

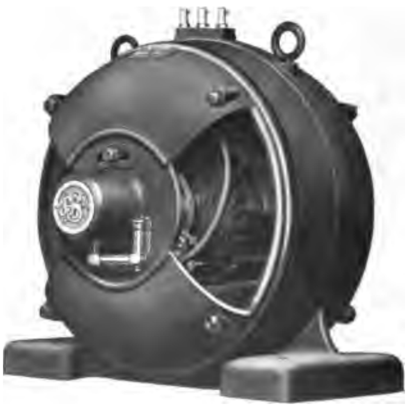

FIG. 120. STURTEVANT BI-POLAR MOTOR.

219. Bi-polar Motors

Bi-polar motors are for direct connection to ventilating fans, and may be either semi-enclosed or enclosed. The frame which forms the magnet ring and the end casings is cast iron. The two pole pieces are made of laminated steel punchings. Field coils are of double cotton covered copper wire, well insulated and made oil and water proof by dipping in armalac and baking for 24 hours. The bearings are of the ring oiling type. The end casings are fastened to the frame by means of four equally spaced bolts arranged so that the motor may be mounted upon the floor, wall or ceiling. The armature is of the slotted drum type and consists of a core of thoroughly insulated soft steel laminations supported on the shaft and slotted to receive form-wound coils. It is thoroughly water proofed with armalac. Only pure hard drawn copper is used for the commutator segments, which are insulated with selected mica. The brushes are carbon and are mounted in brush holders. These motors are wound for standard voltages.

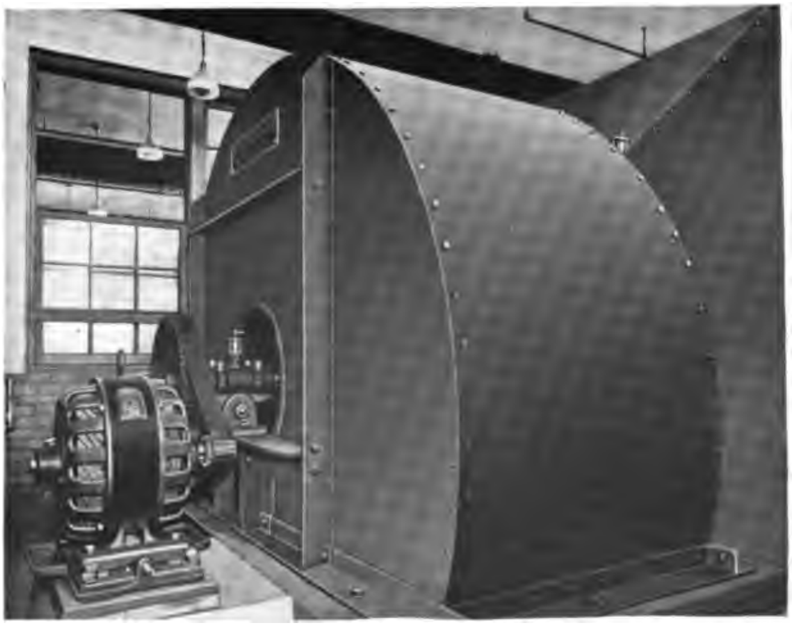

FIG. 121. CHAIN DRIVEN STURTEVANT FAN. PEERLESS MOTOR CAR CO., DETROIT, MICH.

220. Belt and Chain Drive

Although direct connected drive is generally to be preferred wherever it is possible, there are many installations where a belt or chain drive is necessary since the restrictions of space and the limitations of speed sometimes prevent the use of the direct drive.

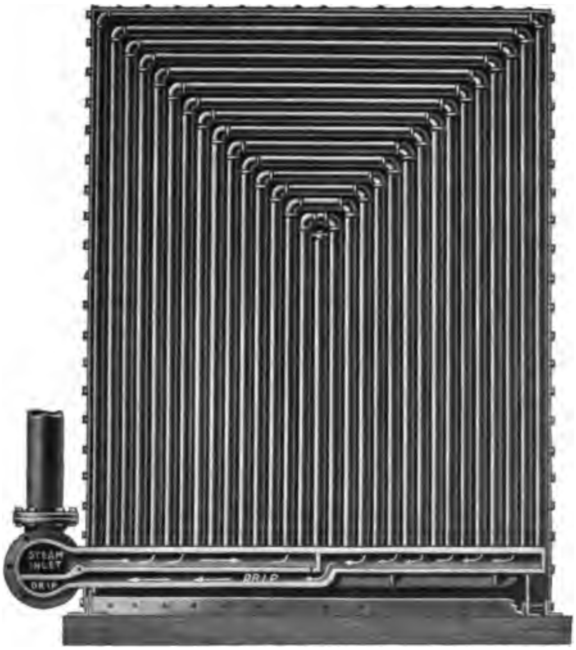

FIG. 122. SECTION STANDARD STURTEVANT HEATER.

In mills and factories, where there is shafting from which a belt may be run to the fan, the belt drive may be more convenient in the day time but an electric motor or steam engine should be provided so that the fan may be operated independently of the shafting.

221. Standard Heaters

Heaters used in the Sturtevant System consist of cast iron bases into which are screwed steel pipes forming the heater coils. These heaters are made in various forms for different applications. They are compact, efficient and self-contained and the construction permits a change of capacity by adding or removing one or more sections.

In Fig. 122 is indicated in detail the general construction of the individual sections of the standard heater. The foundation upon which the heater rests is built entirely of steel angles, bolted together. Upon this rests a series of sectional bases, each section containing either 2 or 4 rows of vertical pipes, according to requirements, connected by cross pipes at the top as shown. The length of these pipes and their position prevents the evil effects of the unequal expansion of the pairs of vertical pipes. Free expansion of the section lengthwise is allowed for by placing one end of the section on a steel angle.

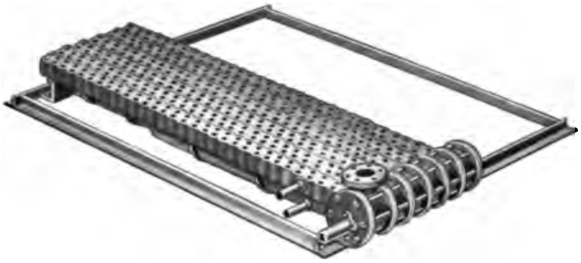
FIG. 123. STANDARD STURTEVANT HEATER BASE.

In order to prevent alternate expansion and contraction of the air between the pipes of the heaters and at the same time economize space and material, the sides of the section are corrugated so that they fit each other closely and allow uniform spacing of the pipes in the heater.

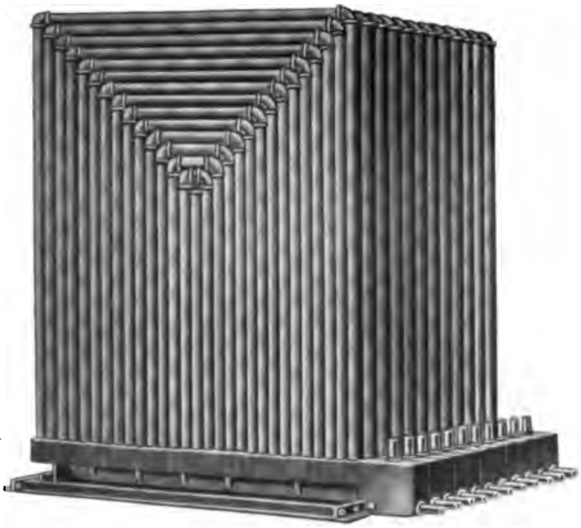
FIG. 124. STURTEVANT "LONDON" TYPE HEATER.

Upon the end of each section is a circular flanged head, divided by a horizontal diaphragm, the upper part communicating with the steam supply, and the lower with the drip. The sides of the heads are surfaced and closely fitted. A blank flange is placed at one end of the series and the large steam inlet and drip header at the other. These heads are tightly drawn together by strong through bolts, and tight joints are positively secured by the use of special gaskets. The upper parts of all these sections thus communicate with the inlet and the lower part with the drip.

Steam is admitted through the steam pipe, passes into the sections, thence up, over and down the pipes, into the separated space in the sections which communicates with the drip, whence it leaves the heater as water of condensation, through the drip pipe. Every square inch of the heating surface of the pipes and sections is thus utilized and the water is conveyed away through the lower part of the heater, into the upper part of which steam is admitted. A small hole in the horizontal diaphragm near the middle of the section allows of complete drainage of the water from each section.

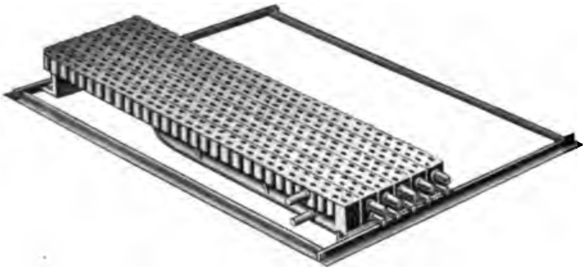

FIG. 125. STURTEVANT HEATER BASE, INDEPENDENT SECTIONS.

222. Heaters, Special Type

The " London " type of heater base is provided with a separate inlet and drip pipe for each section. The base is of the corrugated type with staggered pipes that are arranged in the same manner as those in the standard heater. With this type of heater base, individual sections may be used, if desired, by opening or closing separate valves. A similar arrangement of independent sections is shown in the heater base of Fig. 125.

223. Exhaust Type

The " Exhaust " section is tapped for inlet and drip pipes in the side of the base and is installed in a heater for receiving the exhaust from the fan engine. It is then independent of the main sections of the heater and the oily stream from the engine is not allowed to mix with the steam supply. A corrugated base with staggered pipes is used and the pipe arrangement is similar to that of standard heaters.

The section into which is discharged the fan engine exhaust is always placed so as to be the first with which the cold air comes in contact, because exhaust steam, having a lower temperature than live steam, would have but little effect in heating air which had already passed over the live steam coil. In heating many establishments, it is customary to use, in the main group, the exhaust from the mill or shop engine during the day, and live steam during the night.

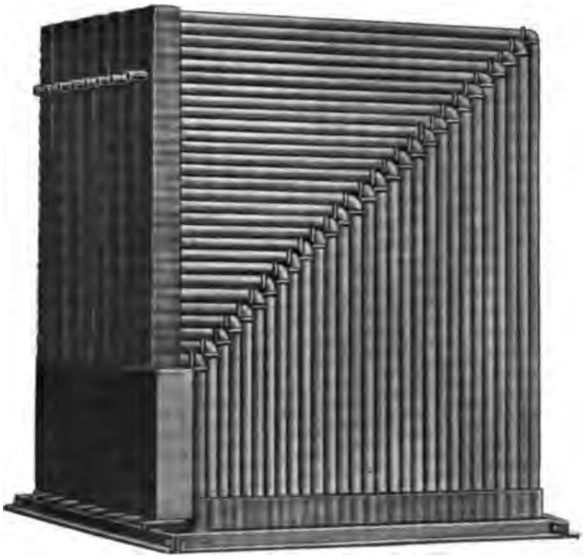

Fig. 126. Sturtevant Mitre Type Heater.

224. Mitre Type

The " Mitre " type section has two bases of the corrugated type set at right angles to each other. The pipe arrangement is entirely different from standard heaters, there being a set of pipes for each base, one arranged horizontally and the other vertically, the ends of the two sets of pipe being connected by means of 90 degree elbows. Steam is admitted at the top, flows through the horizontal and then the vertical pipes, the drip being taken from the lower heater base. When hot water is employed as a heating medium, this form of heater is used, as it offers less resistance to the flow of water through it. When the length of the horizontal pipes in the mitre type of heater requires it, a supporting diaphragm is used to prevent the sagging of these pipes.

225. Monogram Exhausters and Solid Base Heaters

In the smallest sizes of heating and ventilating apparatus in which a cased fan is used in connection with a heater, the arrangement is as shown in Fig. 127. The Monogram type of fan is used. The type of heater is known as the " Solid Base Heater " and is distinguished from the corrugated sectional base heaters used with larger fans by the fact that only a single casting is used for the entire heater base. The steam supply pipe for these heaters enters the base at the bottom on one side and the water of condensation escapes from the bottom on the other side. A diaphragm in the base compels the steam to flow through all the pipes, thus utilizing all the heating surface. The pipes are of steel and the heater is entirely encased in steel plate with a receiving chamber for the air, where it enters the fan. Ordinarily the air is taken in at the

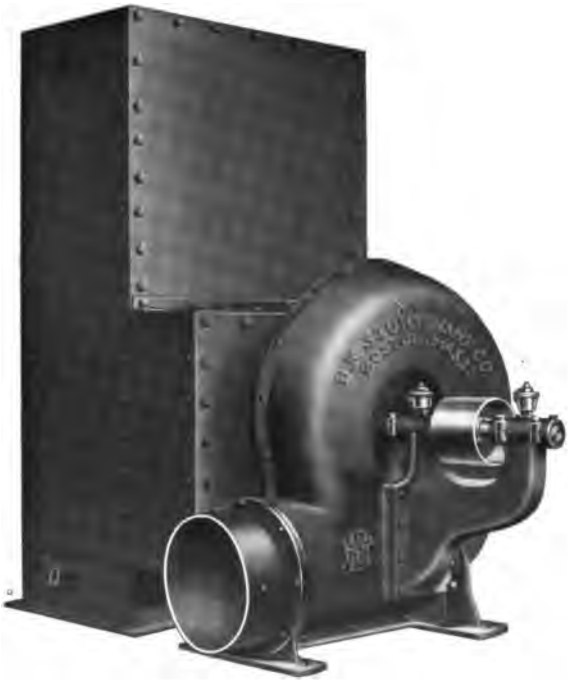

FIG. 127. STURTEVANT SOLID BASE HEATER AND FAN.

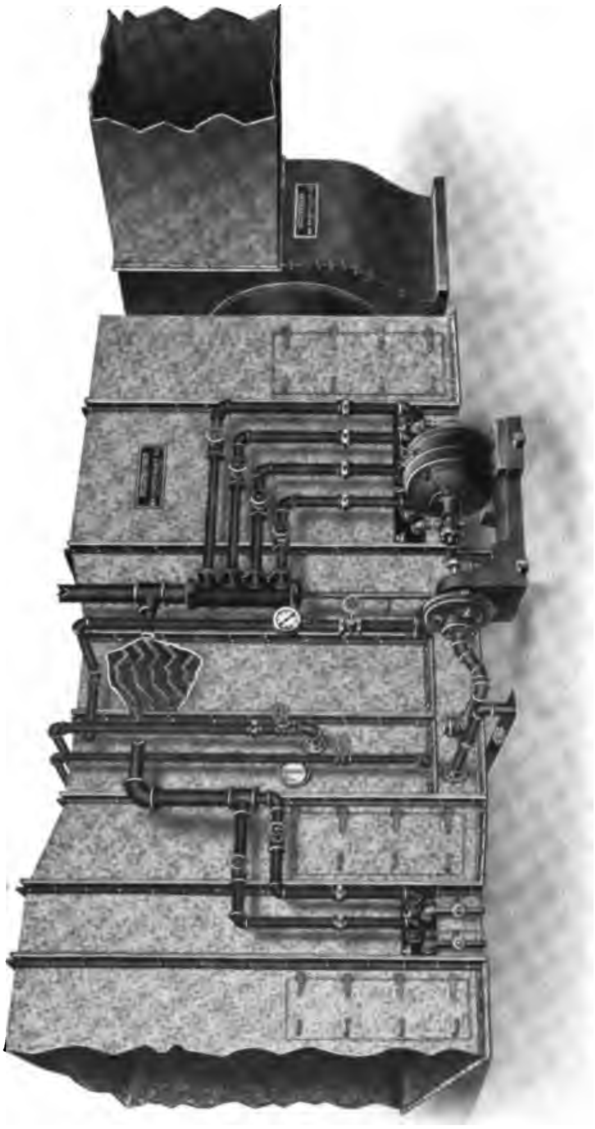

FIG. 128. STURTEVANT AIRWASHER WITH HEATERS AND FAN.

top, either from the room or through a pipe connecting with the desired air supply. The air discharged from the fan can be conveyed to any point by means of a distributing pipe. The heater is designed to use either live or exhaust steam.

226. The Sturtevant Air Washer

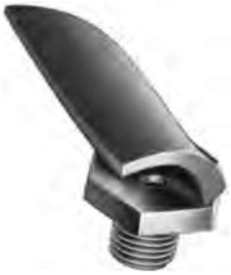

FIG. 129. SPRAY NOZZLE.

The Sturtevant air washer consists of three essential parts, the spray chamber, the eliminators, and the sump or tank which forms the base and into which the water used in the washer falls. The rain type of spray is used, as being the most effective and best adapted for air washing purposes. (See Sections 84 to 89.) With proper modifications, the air washer may be used for humidifying the air. These washers are made and rated for various air volumes per minute. Dimensions and capacities will be found in Table No. 42. Copper may be used for the construction of air washer casings, sumps and eliminators, if preferred, although this is an extra expense that is generally unwarranted, the galvanized steel construction being sufficiently satisfactory and durable for ordinary purposes.

227. The Spray Chamber

The spray chamber housing is built of heavy galvanized steel, fastened together and stiffened with angles. It encloses the spray chamber on the top and sides, the ends being open for the passage of air and the bottom being closed by the sump. In the side of the casing there are inspection holes, fitted with glass covers, so that the performance of the air washer may be observed during operation.

The spray is formed by water issuing from the nozzle and being broken into a rain-like spray by striking against a portion of the nozzle which curls over the orifice through which the water issues. The unique construction of the nozzle is plainly shown by Fig. 129. Creating the spray in this manner rather than by atomizing the water as it issues from the orifice or by placing a flat disc directly over the orifice, as is done in many washers, permits the use of a larger orifice, avoiding the liability of clogging, and the necessity of providing flushing devices. Clogging of the nozzles is one of the most common and most serious faults with air washers, and a fault that is eliminated in the Sturtevant washer by the design of the nozzle.

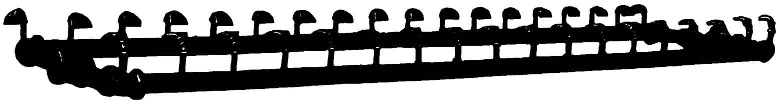

FIG. 130. SPRAY PIPE, STURTEVANT AIR WASHER.

These nozzles are fastened to the spray pipes in a manner shown by Fig. 130, water being supplied under 12 pounds pressure at each end of the loop. As the spray, issuing from the nozzles, is spread out over a wide area, it completely fills the interior of the chamber so that all the air must pass through it. Two or more of these loops of nozzles or spray pipes are used, according to the size of the washer.

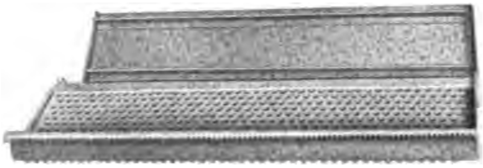

FIG. 131. ELIMINATOR.

228. Eliminators

The arrangement of the eliminators is shown in Fig. 25. These eliminators are of galvanized steel. They are of the horizontal type arranged across the end of the spray chamber and slanted like a louvre. As can be seen in Fig. 131, the edges are serrated to provide points from which water will drip and they are punched to form lips which are bent away from the surface of the eliminators. The air strikes against these lips and the entrained water is removed. This water, dripping from the lips of the eliminators into the sump below, adds further to the efficiency of the washer. By the construction and arrangement of the eliminators, no entrained moisture is carried over with the air by the fan.

229. Sump

The sump is a tank which forms the base of the air washer. It is constructed of galvanized steel or cement, as desired, and catches all the drip from the nozzles and eliminators. A connection to the sewer is provided for draining the sump. For reasons of economy, the water is used over and over again in an air washer, the necessary pressure being furnished by a recirculating pump of the rotary or centrifugal type. A strainer is also provided so that no sediment or fibrous material washed from the air enters the nozzles. This strainer is shown in Fig. 132 and is constructed of two concentric cylindrical screens with solid end plates. The suction pipe from the pump is introduced into the inner screen so that the water passes through both of the strainers. The pump, shown in Fig. 133, is of the centrifugal type and is direct connected to an electric motor.

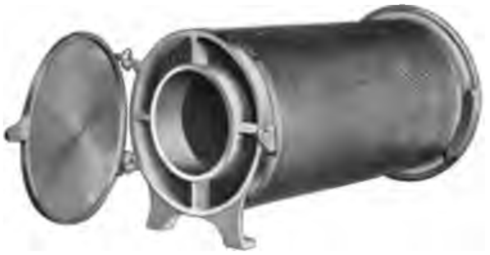

Fig. 132. Strainer, Sturtevant Air Washer.

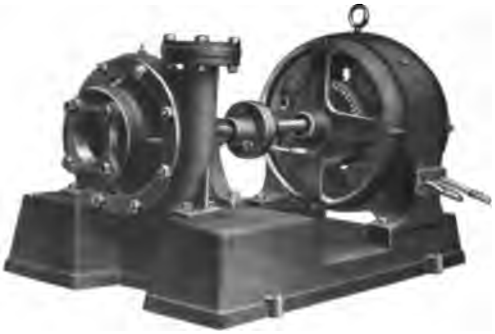

Fig. 133. Electric Air Washer Pump.

230. Automatic Return Water Apparatus

Economy demands that in any heating plant the water of condensation from the steam shall be returned to the boiler. With a simple gravity system or with a hot blast apparatus placed sufficiently above the water level of the boiler, the matter of return of water is simple. But the ordinary plant for the blower system is placed upon the floor, generally well below the level of the boilers. Some positive and additional means is therefore necessary to lift the water and force it into the boiler against the existing steam pressure.

For this purpose, in plants of any reasonable size, a steam pump is employed. The water escaping from the heater is first discharged into a tank which is provided with a float valve, by the action of which steam is admitted to the pump when the water reaches a certain level within the tank. The pump, thus set in motion, operates until the water has been reduced to such a level that the float acts again, but this time closes the steam admission to the pump. The usual form of the combination of pump and receiver is shown in Fig. 135. The latter is so placed with relation to the pump as to permit of the natural flow of water thereto. A gauge glass on the receiver indicates the water level within. The pump is of the duplex pattern, always to be chosen for this class of work, as it ensures more steady running and is far less liable to stoppage than a single piston pump.

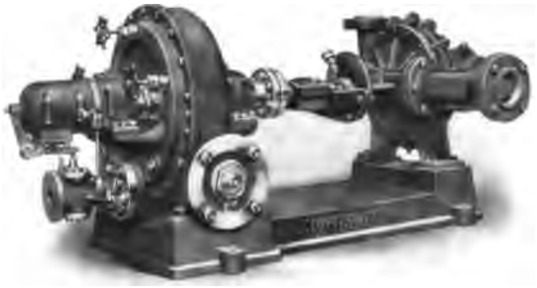
FIG. 134. STURTEVANT TURBO AIR WASHER PUMP.

When water of condensation is to be discharged into the receiver from several sources, as from direct radiators in the building and from a regular hot blast heater at the same time, it is necessary that traps be interposed, otherwise unequal condensation in different groups or coils will tend to a backing up of water in those in which the condensation is most rapid, and hence the pressure is least. With exhaust steam discharged directly into the receiver, a trap is positively necessary in the connection from other coils using live steam and discharging into the same receiver.

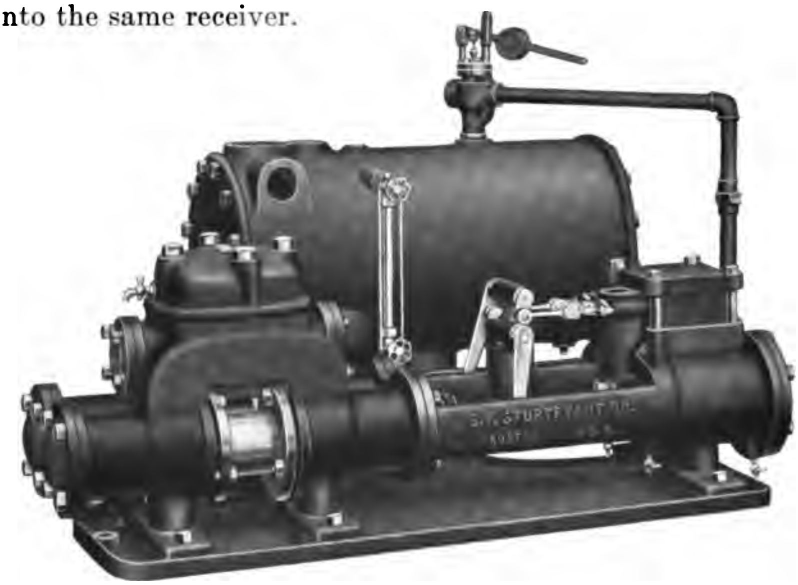

FIG. 135. STURTEVANT RECEIVER AND PUMP.

231. Steam Trap

The Sturtevant steam trap is especially designed for use in connection with Sturtevant heaters, although is it equally well fitted to remove the water of condensation from steam heaters or radiators of any construction. Its action will be made clear by Figs. 136 and 137. As seen in the sectional view, the body of the trap contains a pot, which, as the water flows from the inlet upon the left into the space around the pot, rises and closes the connection between the interior and exterior. The water accumulates in this space and gradually overflows into the pot which sinks to the bottom.

Thus a free passage for the water is afforded from the pot through the vertical hollow extension of the cover and thence through the cored passage in the cover to the outer air or drain. The pressure of the steam upon the surface of the water causes this discharge to be rapid, and it continues until the levity of the pot becomes sufficient to cause it to rise and prevent the passage of water by the seating of the extension against the cone screwed into the bottom of the pot. Both extension and cone are of brass, and are ground to a fit, ensuring a tight joint when in contact.

The periodic delivery of water continues as long as there is water to discharge or sufficient steam pressure to cause the trap to act. These traps are specially constructed to act at different steam pressures.

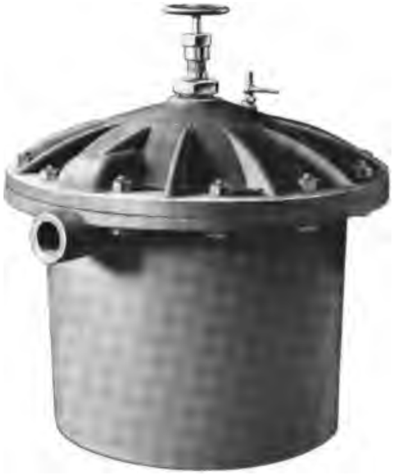

FIG. 136. STURTEVANT STEAM TRAP.

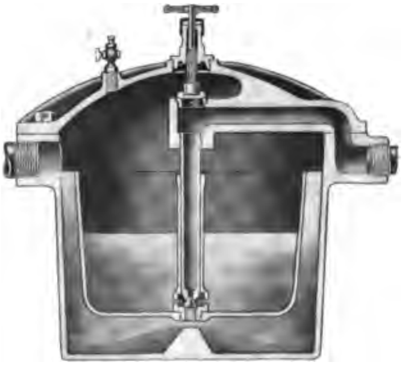

FIG. 137. SECTION STURTEVANT TRAP.

Although certain types of steam traps are designed to return the water of condensation to the boiler, the Sturtevant trap is not intended for this service, but merely to permit of the removal of water from the heater without the escape of steam.

PART II

TABLE NO. 1

WEIGHTS OF AIR, VAPOR OF WATER, AND SATURATED MIXTURES OF AIR AND VAPOR AT DIFFERENT TEMPERATURES, UNDER THE ORDINARY ATMOSPHERIC PRESSURE OF 29.921 INCHES OF MERCURY

Temperature. Fahrenheit.	Volume of Dry Air at different temperatures, the volume at 32° being 1.000.	Weight of a Cubic Foot of Dry Air at different temperatures, in pounds.	Elastic Force of Vapor in Inches of Mercury, Regnault.	MIXTURES OF AIR SATURATED WITH VAPOR.						Cubic Ft. of Vapor from 1 lb. of Water at its own pressure in column 4.
				Elastic Force of the Air in the Mixture of Air and Vapor in Ins. of Mercury.	WEIGHT OF CUBIC FOOT OF THE MIXTURE OF AIR AND VAPOR.			Weight of Vapor mixed with 1 pound of Air in pounds.	Weight of Dry Air mixed with 1 lb. of Vapor in pounds.	
					Weight of the Air in pounds.	Weight of the Vapor in pounds.	Total Weight of Mixture in pounds.			
1	2	3	4	5	6	7	8	9	10	11
0°	.935	.0864	.044	29.877	.0863	.000079	.086379	.00092	1092.4	. . .
12	.960	.0842	.074	29.849	.0840	.000130	.084130	.00155	646.1	. . .
22	.980	.0824	.118	29.803	.0821	.000202	.082302	.00245	406.4	. . .
32	1.000	.0807	.181	29.740	.0802	.000304	.080504	.00379	263.81	3289
42	1.020	.0791	.267	29.654	.0784	.000440	.078840	.00561	178.18	2252
52	1.041	.0776	.388	29.533	.0766	.000627	.077227	.00819	122.17	1595
62	1.061	.0761	.556	29.365	.0747	.000881	.075581	.01179	84.79	1135
72	1.082	.0747	.785	29.136	.0727	.001221	.073921	.01680	59.54	819
82	1.102	.0733	1.092	28.829	.0706	.001667	.072267	.02361	42.35	600
92	1.122	.0720	1.501	28.420	.0684	.002250	.070717	.03289	30.40	444
102	1.143	.0707	2.036	27.885	.0659	.002997	.068897	.04547	21.98	334
112	1.163	.0694	2.731	27.190	.0631	.003946	.067046	.06253	15.99	253
122	1.184	.0682	3.621	26.300	.0599	.005142	.065042	.08584	11.65	194
132	1.204	.0671	4.752	25.169	.0564	.006639	.063039	.11771	8.49	151
142	1.224	.0660	6.165	23.756	.0524	.008473	.060873	.16170	6.18	118
152	1.245	.0649	7.930	21.991	.0477	.010716	.058416	.22465	4.45	93.3
162	1.265	.0638	10.099	19.822	.0423	.013415	.055715	.31713	3.15	74.5
172	1.285	.0628	12.758	17.163	.0360	.016682	.052682	.46338	2.16	59.2
182	1.306	.0618	15.960	13.961	.0288	.020536	.049336	.71300	1.402	48.6
192	1.326	.0609	19.828	10.093	.0205	.025142	.045642	1.22643	.815	39.8
202	1.347	.0600	24.450	5.471	.0109	.030545	.041445	2.80230	.357	32.7
212	1.367	.0591	29.921	0.000	.0000	.036820	.036820	Infinite.	.000	27.1

TABLE NO. 2

INFLUENCE OF TEMPERATURE UPON VAPOR CAPACITY OF AIR

Temperature. Fahrenheit.	Wt. of 1 cu. ft. of Dry Air in pounds.	Relative Volume of Initial Weight.	Vapor Capacity in pounds of Initial cu. ft. of Dry Air at 52° when expanded by given Temperature and by Humidity.									
			Relative Humidity in Per Cent.									
			10	20	30	40	50	60	70	80	90	100
52°	.0776	1.	.00006	.00012	.00019	.00025	.00032	.00038	.00044	.00051	.00057	.00064
62°	.0761	1.02	.00009	.00018	.00027	.00036	.00045	.00055	.00064	.00073	.00082	.00092
72°	.0747	1.04	.00013	.00025	.00038	.00051	.00064	.00077	.00090	.00104	.00117	.00130
82°	.0733	1.06	.00018	.00036	.00054	.00072	.00090	.00108	.00126	.00145	.00164	.00183
92°	.0720	1.08	.00024	.00049	.00077	.00099	.00124	.00150	.00175	.00201	.00228	.00254
102°	.0707	1.10	.00033	.00065	.00101	.00135	.00170	.00245	.00248	.00277	.00314	.00353
112°	.0694	1.12	.00045	.00090	.00136	.00183	.00231	.00280	.00329	.00381	.00433	.00485
122°	.0682	1.14	.00059	.00119	.00182	.00246	.00311	.00378	.00447	.00519	.00590	.00666
132°	.0671	1.16	.00078	.00158	.00242	.00328	.00417	.00510	.00605	.00705	.00806	.00913
142°	.0660	1.18	.00102	.00208	.00318	.00432	.00555	.00684	.00812	.00952	.01098	.0124
152°	.0649	1.20	.00131	.00270	.00417	.00572	.00734	.00912	.0110	.0130	.0156	.01743
162°	.0638	1.22	.00169	.00350	.00545	.00753	.00983	.0126	.0149	.0179	.0201	.0246
172°	.0628	1.24	.00216	.00452	.00708	.00995	.0130	.0166	.0206	.0250	.0300	.0360
182°	.0618	1.26	.00272	.00578	.00920	.0131	.0175	.0227	.0288	.0360	.0446	.0553

TABLE NO. 3

INFLUENCE OF THE TEMPERATURE OF AIR UPON THE CONDITIONS OF ITS MOVEMENT

Temperature in Degrees, Fahr.	Relative Velocity Due to the Same Pressure.	Relative Pressure Necessary to Produce the Same Velocity.	Relative Weight of Air Moved at the Same Velocity.	Relative Velocity Necessary to Move the Same Weight of Air.	Relative Pressure Necessary to Produce the Velocity to Move the Same Weight of Air.	Relative Power Necessary to Move the Same Volume of Air at the Same Velocity.	Relative Power Necessary to Move the Same Weight of Air at the Velocity in Column 5 and the Pressure in Column 6.
1	2	3	4	5	6	7	8
30°	0.98	1.04	1.04	0.96	0.96	1.04	0.92
40	0.99	1.02	1.02	0.98	0.98	1.02	0.96
50	1.00	1.00	1.00	1.00	1.00	1.00	1.00
60	1.01	0.98	0.98	1.02	1.02	0.98	1.04
70	1.02	0.96	0.96	1.04	1.04	0.96	1.08
80	1.03	0.94	0.94	1.06	1.06	0.94	1.12
90	1.04	0.93	0.93	1.08	1.08	0.93	1.17
100	1.05	0.91	0.91	1.10	1.10	0.91	1.21
125	1.07	0.87	0.87	1.15	1.15	0.87	1.32
150	1.09	0.84	0.84	1.20	1.20	0.84	1.43
175	1.11	0.81	0.81	1.24	1.24	0.81	1.55
200	1.14	0.78	0.78	1.29	1.29	0.78	1.67
225	1.16	0.75	0.75	1.34	1.34	0.75	1.80
250	1.18	0.72	0.72	1.39	1.39	0.72	1.93
275	1.20	0.69	0.69	1.44	1.44	0.69	2.07
300	1.22	0.67	0.67	1.49	1.49	0.67	2.22
325	1.24	0.65	0.65	1.54	1.54	0.65	2.36
350	1.26	0.63	0.63	1.59	1.59	0.63	2.51
375	1.28	0.61	0.61	1.63	1.63	0.61	2.66
400	1.30	0.59	0.59	1.68	1.68	0.59	2.82
425	1.32	0.58	0.58	1.73	1.73	0.58	2.99
450	1.34	0.56	0.56	1.78	1.78	0.56	3.17
475	1.35	0.55	0.55	1.83	1.83	0.55	3.35
500	1.37	0.53	0.53	1.88	1.88	0.53	3.53
525	1.39	0.52	0.52	1.93	1.93	0.52	3.72
550	1.41	0.51	0.51	1.98	1.98	0.51	3.92
575	1.43	0.49	0.49	2.03	2.03	0.49	4.12
600	1.44	0.48	0.48	2.08	2.08	0.48	4.33
625	1.46	0.47	0.47	2.13	2.13	0.47	4.54
650	1.48	0.46	0.46	2.18	2.18	0.46	4.75
675	1.49	0.45	0.45	2.22	2.22	0.45	4.93
700	1.51	0.44	0.44	2.27	2.27	0.44	5.15
725	1.52	0.43	0.43	2.32	2.32	0.43	5.38
750	1.54	0.42	0.42	2.37	2.37	0.42	5.62
775	1.56	0.41	0.41	2.42	2.42	0.41	5.86
800	1.57	0.40	0.40	2.47	2.47	0.40	6.10

TABLE NO. 4

RELATION OF VOLUME, WEIGHT AND PRESSURE OF AIR AND SPEED AND POWER OF A FAN WITH AIR AT DIFFERENT TEMPERATURES

Temperature, Degrees Fahr.	Volume for Same Weight.	Weight for Same Volume.	Speed of Fan to Handle Same Weight.	Pressure Difference due to Speed Necessary to Handle Same Weight.	Pressure Difference for Same Speed and Volume.	Speed to Produce Same Pressure Difference.	Power for Same Speed and Volume.	Power for Speed Necessary to Handle Same Weight.	Power Necessary to Handle Same Weight at Same Pressure with a Properly Proportioned Fan.
1	2	3	4	5	6	7	8	9	10
30°	0.96	1.04	0.96	0.96	1.04	0.98	1.04	0.92	0.96
40	0.98	1.02	0.98	0.98	1.02	0.99	1.02	0.96	0.98
50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
60	1.02	0.98	1.02	1.02	0.98	1.01	0.98	1.04	1.02
70	1.04	0.96	1.04	1.04	0.96	1.02	0.96	1.08	1.04
80	1.06	0.94	1.06	1.06	0.94	1.03	0.94	1.12	1.06
90	1.08	0.93	1.08	1.08	0.93	1.04	0.93	1.17	1.08
100	1.10	0.91	1.10	1.10	0.91	1.05	0.91	1.21	1.10
125	1.15	0.87	1.15	1.15	0.87	1.07	0.87	1.32	1.15
150	1.20	0.84	1.20	1.20	0.84	1.09	0.84	1.43	1.20
175	1.24	0.81	1.24	1.24	0.81	1.11	0.81	1.55	1.24
200	1.29	0.78	1.29	1.29	0.78	1.14	0.78	1.67	1.29
225	1.34	0.75	1.34	1.34	0.75	1.16	0.75	1.80	1.34
250	1.39	0.72	1.39	1.39	0.72	1.18	0.72	1.93	1.39
275	1.44	0.69	1.44	1.44	0.69	1.20	0.69	2.07	1.44
300	1.49	0.67	1.49	0.49	0.67	1.22	0.67	2.22	1.49
325	1.54	0.65	1.54	1.54	0.65	1.24	0.65	2.36	1.54
350	1.59	0.63	1.59	1.59	0.63	1.26	0.63	2.51	1.59
375	1.63	0.61	1.63	1.63	0.61	1.28	0.61	2.68	1.63
400	1.68	0.59	1.68	1.68	0.59	1.30	0.59	2.84	1.68
425	1.73	0.58	1.73	1.73	0.58	1.32	0.58	3.01	1.73
450	1.78	0.56	1.78	1.78	0.56	1.34	0.56	3.18	1.78
475	1.83	0.55	1.83	1.83	0.55	1.35	0.55	3.35	1.83
500	1.88	0.53	1.88	1.88	0.53	1.37	0.53	3.56	1.88
525	1.93	0.52	1.93	1.93	0.52	1.39	0.52	3.71	1.93
550	1.98	0.51	1.98	1.98	0.51	1.41	0.51	3.92	1.98
575	2.03	0.49	2.03	2.03	0.49	1.43	0.49	4.12	2.03
600	2.08	0.48	2.08	2.08	0.48	1.44	0.48	4.32	2.08
625	2.13	0.47	2.13	2.13	0.47	1.46	0.47	4.54	2.13
650	2.18	0.46	2.18	2.18	0.46	1.48	0.46	4.75	2.18
675	2.22	0.45	2.22	2.22	0.45	1.49	0.45	4.93	2.22
700	2.27	0.44	2.27	2.27	0.44	1.51	0.44	5.16	2.27
725	2.32	0.43	2.32	2.32	0.43	1.52	0.43	5.39	2.32
750	2.37	0.42	2.37	2.37	0.42	1.54	0.42	5.62	2.37
775	2.42	0.41	2.42	2.42	0.41	1.56	0.41	5.86	2.42
800	2.47	0.40	2.47	2.47	0.40	1.57	0.40	6.10	2.47

TABLE NO. 5

PRESSURE AND HORSE POWER LOST BY FRICTION OF AIR IN PIPES 100 FEET LONG

Diameter of Pipe in Inches.	Loss of Pressure and Horse Power.	VELOCITY OF AIR IN FEET PER MINUTE.										
		1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000
12	In. of water	.159	.229	.312	.408	.517	.638	.772	.920	1.080	1.250	1.420
	Ounces	.092	.133	.181	.237	.300	.370	.448	.533	.626	.726	.833
	H.P.,friction	.0198	.0343	.0544	.0812	.1156	.1586	.2111	.2741	.3485	.4353	.5354
18	In. of water	.107	.154	.2085	.273	.345	.426	.516	.613	.719	.835	.959
	Ounces	.062	.089	.121	.158	.200	.247	.299	.356	.417	.484	.556
	H. P.	.0297	.0512	.0816	.1218	.1735	.2380	.3167	.4112	.5228	.6530	.8031
24	In. of water	.079	.116	.157	.205	.258	.319	.386	.460	.539	.626	.719
	Ounces	.046	.067	.091	.119	.150	.185	.224	.267	.313	.363	.417
	H. P.	.0397	.0685	.1088	.1624	.2313	.3173	.4223	.5483	.6971	.8706	1.0708
30	In. of water	.064	.091	.126	.164	.207	.255	.308	.367	.431	.500	.577
	Ounces	.037	.053	.073	.095	.120	.148	.179	.213	.250	.290	.333
	H. P.	.0496	.0857	.1360	.2031	.2891	.3966	.5279	.6855	.8714	1.0884	1.3388
36	In. of water	.053	.076	.103	.136	.173	.212	.257	.307	.362	.417	.478
	Ounces	.031	.044	.060	.079	.100	.123	.149	.178	.209	.242	.278
	H. P.	.0595	.1024	.1632	.2437	.3469	.4759	.6334	.8224	1.0456	1.3059	1.6062
40	In. of water	.048	.096	.093	.122	.155	.191	.231	.276	.324	.376	.431
	Ounces	.028	.040	.054	.071	.090	.111	.134	.160	.188	.218	.250
	H. P.	.0661	.1142	.1814	.2707	.3855	.5288	.7038	.9138	1.1618	1.4510	1.7847
44	In. of water	.043	.062	.085	.119	.141	.174	.212	.250	.295	.342	.391
	Ounces	.025	.036	.049	.069	.082	.101	.122	.145	.171	.198	.227
	H. P.	.0727	.1256	.1995	.2938	.4240	.5817	.7742	1.0051	1.2779	1.5961	1.9632
48	In. of water	.039	.057	.078	.102	.129	.160	.193	.231	.269	.312	.359
	Ounces	.023	.033	.045	.059	.075	.093	.112	.133	.156	.181	.208
	H. P.	.0793	.1371	.0217	.3249	.4626	.6346	.8446	1.0965	1.3941	1.7412	2.1416
52	In. of water	.036	.053	.072	.095	.119	.146	.178	.212	.248	.289	.331
	Ounces	.021	.031	.042	.055	.069	.085	.103	.123	.144	.168	.192
	H. P.	.0859	.1485	.2360	.3520	.5011	.6874	.9150	1.1879	1.5103	1.8864	2.3201
56	In. of water	.034	.050	.067	.088	.110	.136	.165	.205	.232	.269	.308
	Ounces	.020	.029	.039	.051	.064	.079	.096	.119	.134	.156	.179
	H. P.	.0925	.1599	.2539	.3790	.5406	.7403	.9854	1.2793	1.6265	2.0314	2.4979
60	In. of water	.033	.047	.062	.081	.104	.128	.150	.185	.216	.250	.288
	Ounces	.019	.027	.036	.047	.060	.074	.090	.107	.125	.145	.167
	H. P.	.0991	.1713	.2721	.4061	.5782	.7932	1.1607	1.3706	1.7427	2.1765	2.6771

TABLE NO. 6

VELOCITY CREATED WHEN AIR UNDER A GIVEN PRESSURE IN INCHES OF WATER IS ALLOWED TO ESCAPE INTO THE ATMOSPHERE

Pressure in Inches of Water, per Square Inch.	Velocity of Dry Air at 50° Temperature Escaping into the Atmosphere through any Shaped Orifice in any Pipe or Reservoir in which the Given Pressure is Maintained.		Pressure in Inches of Water, per Square Inch.	Velocity of Dry Air at 50° Temperature Escaping into the Atmosphere through any Shaped Orifice in any Pipe or Reservoir in which the Given Pressure is Maintained	
	In Feet per Second.	In Feet per Minute.		In Feet per Second.	In Feet per Minute.
0.1	20.72	1,243.3	2.6	105.33	6,320.0
0.2	29.30	1,758.0	2.7	107.33	6,439.7
0.3	35.84	2,150.4	2.8	109.28	6,557.0
0.4	41.43	2,485.6	2.9	111.21	6,672.3
0.5	46.31	2,778.7	3.0	113.09	6,785.5
0.6	50.73	3,043.5	3.1	114.95	6,896.8
0.7	54.78	3,287.0	3.2	116.77	7,006.3
0.8	58.56	3,513.5	3.3	118.57	7,114.1
0.9	62.10	3,726.1	3.4	120.34	7,220.2
1.0	65.45	3,927.2	3.5	122.08	7,324.7
1.1	68.64	4,118.4	3.6	123.80	7,427.7
1.2	71.68	4,301.0	3.7	125.49	7,529.3
1.3	74.60	4,476.1	3.8	127.16	7,629.4
1.4	77.41	4,644.5	3.9	128.80	7,728.2
1.5	80.12	4,806.9	4.0	130.43	7,825.7
1.6	82.73	4,963.9	4.25	134.40	8,064.1
1.7	85.27	5,116.1	4.5	138.26	8,295.4
1.8	87.73	5,263.7	4.75	142.00	8,520.1
1.9	90.12	5,407.3	5	145.65	8,738.8
2.0	92.45	5,547.1	5.25	149.20	8,951.8
2.1	94.72	5,683.4	5.5	152.66	9,159.7
2.2	96.94	5,816.5	5.75	156.05	9,362.8
2.3	99.11	5,946.4	6	159.35	9,561.2
2.4	101.23	6,073.6	6.25	162.59	9,755.4
2.5	103.30	6,198.1	6.50	165.76	9,945.8

TABLE NO. 7

VELOCITY, VOLUME, AND HORSE POWER REQUIRED WHEN AIR UNDER GIVEN PRESSURE IN OUNCES PER SQUARE INCH IS ALLOWED TO ESCAPE INTO THE ATMOSPHERE

Pressure in Ounces.	Velocity of Dry Air at 50° Temperature Fahr. Escaping into the Atmosphere through any Shaped Orifice in any Pipe or Reservoir in which the Given Pressure is Maintained.		Volume of Air in Cubic Feet which may be Discharged in One Minute through an Orifice having an Effective Area of Discharge of One Square Inch.	Horse Power required to move the Given Volume of Air under the Given Conditions.
Per square Inch.	In Feet per Second.	In Feet per Minute.		
⅛	30.47	1,828.4	12.69	0.00043
¼	43.08	2,585.0	17.95	0.00122
⅜	52.75	3,165.1	21.98	0.00225
½	60.90	3,653.8	25.37	0.00346
⅝	68.07	4,084.0	28.36	0.00483
¾	74.54	4,472.6	31.06	0.00635
⅞	80.50	4,829.7	33.54	0.00800
1	86.03	5,161.7	35.85	0.00978
1⅛	91.22	5,473.4	38.01	0.01166
1¼	96.13	5,768.0	40.06	0.01366
1⅜	100.80	6,047.9	42.00	0.01575
1½	105.25	6,315.2	43.86	0.01794
1⅝	109.52	6,571.3	45.63	0.02022
1¾	113.64	6,817.6	47.34	0.02260
1⅞	117.58	7,055.0	49.00	0.02505
2	121.41	7,284.4	50.59	0.02759
2⅛	125.11	7,506.7	52.13	0.03021
2¼	128.70	7,722.2	53.63	0.03291
2⅜	132.20	7,931.8	55.08	0.03568
2½	135.59	8,135.7	56.50	0.03852
2⅝	138.91	8,334.4	57.88	0.04144
2¾	142.14	8,528.3	59.22	0.04442
2⅞	145.29	8,717.6	60.54	0.04747
3	148.38	8,902.8	61.83	0.05058
3⅛	151.40	9,084.0	63.08	0.05376
3¼	154.36	9,261.5	64.32	0.05701
3⅜	157.26	9,435.4	65.52	0.06031
3½	160.10	9,606.1	66.71	0.06368
3⅝	162.89	9,773.3	67.87	0.06710
3¾	165.63	9,938.0	69.01	0.07058
3⅞	168.33	10,099.6	70.14	0.07412

Continued on next page.

TABLE NO. 7 (*Concluded*)

VELOCITY, VOLUME, AND HORSE POWER REQUIRED WHEN AIR UNDER GIVEN PRESSURE IN OUNCES PER SQUARE INCH IS ALLOWED TO ESCAPE INTO THE ATMOSPHERE

Pressure.	Velocity per Second.	Velocity per Minute.	Volume.	Horse Power.
4	170.98	10,258.6	71.24	0.07771
4¼	176.15	10,568.8	73.39	0.08507
4½	181.16	10,869.5	75.48	0.09264
4¾	186.03	11,161.5	77.51	0.1004
5	190.76	11,445.5	79.48	0.1084
5¼	195.37	11,722.0	81.40	0.1166
5½	199.86	11,991.5	83.24	0.1249
5¾	204.25	12,254.8	85.10	0.1335
6	208.53	12,511.9	86.89	0.1422
6½	216.82	13,009.3	90.34	0.1602
7	224.77	13,486.4	93.66	0.1788
7½	232.42	13,945.4	96.84	0.1981
8	239.80	14,387.9	99.92	0.2180
8½	246.92	14,815.4	102.88	0.2385
9	253.83	15,229.6	105.76	0.2596
9½	260.52	15,631.0	108.55	0.2812
10	267.00	16,020.4	111.25	0.3034
10½	273.32	16,399.3	113.88	0.3261
11	279.70	16,768.1	116.45	0.3493
11½	285.46	17,127.6	118.94	0.3730
12	291.30	17,478.2	121.38	0.3972
12½	297.01	17,820.6	123.75	0.4219
13	302.59	18,155.2	126.06	0.4470
13½	308.04	18,482.4	128.35	0.4726
14	313.38	18,802.7	130.57	0.4986
14½	318.61	19,116.3	132.75	0.5250
15	323.73	19,423.6	134.89	0.5518
15½	328.75	19,725.0	136.98	0.5791
16	333.68	20,020.7	139.03	0.6067
16½	338.51	20,310.8	141.05	0.6347
17	343.26	20,595.8	143.03	0.6631
17½	347.93	20,875.8	144.97	0.6919
18	352.52	21,151.0	146.88	0.7211
18½	357.03	21,421.6	148.76	0.7506
19	361.46	21,687.8	150.61	0.7804
19½	365.83	21,949.7	152.43	0.8107
20	370.13	22,207.5	154.22	0.8412

TABLE NO. 8

PROPERTIES OF SATURATED STEAM

Total Pressure, in lbs. per Sq. In., Measured from a Vacuum.	Temperature, in Degrees Fahrenheit of Steam and of the Water from which it was Evaporated.	Number of British Thermal Units Contained in One Pound Reckoned from Zero Fahrenheit.		Weight of One Cubic Foot of Steam, in Decimals of a Pound.	Volume of One Pound of Steam, in Cubic Feet.	Relative Volume or Cubic Feet of Steam from one Cubic Foot of Water.
		Number Required for Evaporation, Known as Latent Heat, or Heat of Vaporization.	Total Number Contained in the Steam.			
1	101.84	1034.7	1136.5	.0030	333.10	20750.0
2	126.15	1021.9	1148.1	.0057	173.10	10790.0
3	141.52	1012.2	1153.8	.0084	118.40	7380.0
4	153.00	1005.5	1158.5	.0110	90.40	5630.0
5	162.26	1000.0	1162.3	.0136	73.30	4570.0
6	170.07	995.5	1165.6	.0161	61.90	3855.0
7	176.84	991.4	1168.3	.0186	53.60	3340.0
8	182.86	987.8	1170.7	.0211	47.26	2942.0
9	188.27	984.5	1172.9	.0236	42.36	2640.0
10	193.21	981.4	1174.7	.0260	38.37	2390.0
12	201.95	976.0	1178.1	.0308	32.40	2020.0
14	209.55	971.2	1181.0	.0356	28.03	1746.0
14.7	212.00	965.7	1181.8	.0380	26.36	1644.0
16	216.31	967.0	1183.6	.0404	24.74	1541.0
18	222.40	963.1	1185.9	.0451	22.17	1380.0
20	222.95	959.4	1187.8	.0497	20.09	1250.0
22	233.07	956.0	1189.6	.0544	18.37	1144.0
24	237.82	952.9	1191.3	.0591	16.92	1054.0
26	242.26	949.9	1192.8	.0637	15.70	979.0
28	246.41	947.1	1194.2	.0682	14.67	915.0
30	250.34	944.4	1195.5	.0728	13.74	856.5
32	254.05	941.8	1196.7	.0773	12.93	805.5
34	257.59	939.4	1197.9	.0819	12.21	761.5
36	260.96	937.1	1199.0	.0864	11.58	722.4
38	264.17	934.8	1200.0	.0908	11.01	686.5
40	267.26	932.6	1201.0	.0953	10.47	654.0
42	270.23	930.6	1202.0	.0998	10.02	625.0
44	273.07	928.5	1202.8	.1043	9.589	597.5
46	275.82	926.6	1203.7	.1087	9.195	572.6
48	278.47	924.7	1204.5	.1131	8.838	550.0
50	281.03	922.8	1205.2	.1176	8.507	530.3
52	283.52	921.0	1206.0	.1220	8.198	510.0
54	285.93	919.3	1206.7	.1264	7.912	492.7
56	288.25	917.6	1207.4	.1308	7.647	476.0
58	290.53	915.9	1208.0	.1352	7.397	460.5

Continued on next page.

TABLE NO. 8 (*Concluded*)

PROPERTIES OF SATURATED STEAM

Total Pressure, in lbs. per Sq. In.	Temperature, in Degrees Fahrenheit of Steam, etc.	Number of B. T. U., etc.		Weight of One Cubic Foot of Steam, etc.	Volume of One Pound of Steam, in Cubic Feet.	Relative Volume or Cubic Feet Steam, etc.
		Number Required for Evaporation.	Total Number Contained, etc.			
60	292.74	914.3	1208.7	.1395	7.166	446.5
62	294.88	912.7	1209.3	.1439	6.949	432.5
64	296.97	911.1	1209.8	.1483	6.745	420.0
66	299.02	909.6	1210.4	.1526	6.552	408.0
68	301.01	908.1	1211.0	.1570	6.370	397.0
70	302.96	906.6	1211.5	.1613	6.199	388.0
72	304.86	905.2	1212.0	.1657	6.036	376.0.
74	306.72	903.8	1212.5	.1700	5.882	366.8
76	308.54	902.4	1213.0	.1744	5.735	357.4
78	310.33	901.1	1213.5	.1787	5.597	348.5
80	312.08	899.8	1214.0	.1829	5.466	340.5
82	313.79	898.5	1214.4	.1872	5.342	332.8
84	315.47	897.2	1214.9	.1916	5.220	324.7
86	317.12	895.9	1215.3	.1959	5.104	318.0
88	318.73	894.7	1215.7	.2003	4.993	311.3
90	320.32	893.5	1216.2	.2047	4.886	304.5
92	321.88	892.3	1216.6	.2090	4.785	298.2
94	323.41	891.1	1217.0	.2133	4.689	292.0
96	324.91	889.9	1217.3	.2174	5.599	286.4
98	326.40	888.7	1217.6	.2215	4.514	281.0
100	327.86	887.6	1218.1	.2256	4.432	276.2
110	334.83	882.1	1219.7	.2471	4.047	252.0
120	341.31	876.9	1221.2	.2686	3.723	232.0
130	347.38	872.1	1222.7	.2898	3.451	215.0
140	353.09	867.4	1223.8	.3106	3.220	200.8
150	358.50	863.0	1225.0	.3318	3.014	187.9
160	363.62	858.8	1226.1	.3528	2.834	176.7
170	368.50	854.8	1227.2	.3741	2.673	166.5
180	373.16	850.9	1237.1	.3951	2.531	157.7
190	377.61	847.1	1228.9	.4158	2.405	149.8
200	381.89	843.5	1229.8	.4371	2.288	142.6
215	388.02	838.3	1230.9	.4682	2.136	133.0
230	393.80	833.3	1231.9	.4997	2.001	124.8
245	399.32	828.5	1232.9	.5310	1.882	117.3
260	404.55	823.9	1233.7	.5630	1.775	110.6
275	409.57	819.5	1234.6	.5950	1.681	104.8
290	414.35	815.2	1235.3	.6270	1.595	99.5
305	418.97	811.1	1236.0	.6590	1.517	94.6
320	423.40	807.1	1236.6	.6920	1.446	90.1
335	427.67	803.2	1237.2	.7240	1.381	86.2

TABLE NO. 9

NUMBER OF THERMAL UNITS CONTAINED IN ONE POUND OF WATER

Temp.	Thermal Units.	Temp.	Thermal Units.	Temp.	Thermal Units.	Temp.	Thermal Units.	Temp.	Thermal Units.	Temp.	Thermal Units.
32	0.0	102	70.0	172	140	242	210.7	312	282.1	382	354.4
34	2.0	104	72.0	174	142	244	212.7	314	284.2	384	356.5
36	4.0	106	74.0	176	144	246	214.7	316	286.2	386	358.5
38	6.1	108	76.0	178	146	248	216.7	318	288.3	388	360.6
40	8.1	110	78.0	180	148	250	218.8	320	290.4	390	362.7
42	10.1	112	80.0	182	150.1	252	220.8	322	292.4	392	364.8
44	12.1	114	82.0	184	152.1	254	222.8	324	294.5	394	366.9
46	14.1	116	84.0	186	154.1	256	224.9	326	296.5	396	368.9
48	16.1	118	86.0	188	156.1	258	226.9	328	298.6	398	371
50	18.1	120	88.0	190	158.1	260	229	330	300.6	400	373.1
52	20.1	122	90.0	192	160.1	262	231	332	302.7	402	375.2
54	22.1	124	92.0	194	162.1	264	233	334	304.8	404	377.3
56	24.1	126	94.0	196	164.1	266	235	336	306.8	406	379.4
58	26.1	128	96.0	198	166.2	268	237.1	338	308.9	408	381.4
60	28.1	130	98.0	200	168.2	270	239.1	340	310.9	410	383.5
62	30.1	132	100.0	202	170.2	272	241.2	342	313	412	385.6
64	32.1	134	102.0	204	172.2	274	243.2	344	315.1	414	387.7
66	34.1	136	104.0	206	174.2	276	245.3	346	317.1	416	389.8
68	36.1	138	106.0	208	176.2	278	247.3	348	319.2	418	391.9
70	38.1	140	108.0	210	178.3	280	249.4	350	321.3	420	394
72	40.1	142	110.0	212	180.3	282	251.4	352	322.3	422	396.1
74	42.1	144	112.0	214	182.3	284	253.4	354	325.4	424	398.2
76	44.1	146	114.0	216	184.3	286	255.5	356	327.5	426	400.3
78	46.1	148	116.0	218	186.3	288	257.5	358	329.5	428	402.3
80	48.1	150	118.0	220	188.4	290	259.6	360	331.6	. .	. .
82	50.1	152	120.0	222	190.4	292	261.6	362	333.7	. .	. .
84	52.1	154	122.0	224	192.4	294	263.7	364	335.7	. .	. .
86	54.1	156	124.0	226	194.4	296	265.7	366	337.8	. .	. .
88	56.1	158	126.0	228	196.5	298	267.8	368	339.9	. .	. .
90	58.1	160	128.0	230	198.5	300	269.8	370	341.9	. .	. .
92	60.1	162	130.0	232	200.5	302	271.9	372	344	. .	. .
94	62.1	164	132.0	234	202.5	304	273.9	374	346.1	. .	. .
96	64.1	166	134.0	236	204.6	306	276	376	348.2	. .	. .
98	66.0	168	136.0	238	206.6	308	278	378	350.2	. .	. .
100	68.0	170	138.0	240	208.6	310	280.1	380	352.3	. .	. .

TABLE NO. 10

NUMBER OF CUBIC FEET OF DRY AIR THAT MAY BE HEATED THROUGH 1° (F.) BY THE CONDENSATION OF ONE POUND OF STEAM

Steam Pressure above Vacuum.	Initial Temperature of Air.										
	0°	12°	22°	32°	42°	52°	62°	72°	82°	92°	102°
15	46,946	48,358	49,424	50,393	51,479	52,486	53,494	54,463	55,529	56,566	57,176
20	46,674	47,874	48,929	49,888	50,944	51,961	52,958	53,918	54,973	56,000	56,604
25	46,285	47,473	48,521	49,472	50,519	51,527	52,517	53,468	54,515	55,523	56,132
30	45,925	47,125	48,164	49,108	50,147	51,148	52,130	53,075	54,114	55,124	55,719
35	45,643	46,816	47,848	48,786	49,818	50,812	51,788	52,726	53,758	54,762	55,353
40	45,371	46,536	47,562	48,495	49,521	50,509	51,479	52,412	53,437	54,435	55,023
45	45,122	46,283	47,302	48,230	49,250	50,233	51,198	52,125	53,145	54,138	54,722
50	44,884	46,047	47,062	47,985	49,000	49,978	50,938	51,861	52,876	53,863	54,445
55	44,680	45,828	46,838	47,756	48,749	49,740	50,695	51,614	52,624	53,607	54,185
60	44,480	45,623	46,629	47,543	48,531	49,488	50,479	51,383	52,389	53,367	53,943
65	44,290	45,428	46,430	47,340	48,342	49,306	50,254	51,164	52,165	53,140	53,713
70	44,106	45,239	46,236	47,143	48,140	49,101	50,044	50,950	51,948	52,918	53,489
75	43,935	45,064	46,058	46,971	47,954	48,911	49,851	50,754	51,747	52,713	53,282
80	43,775	44,900	45,889	46,789	47,779	48,733	49,668	50,568	51,458	52,521	53,088
85	43,619	44,740	45,726	46,623	47,609	48,559	49,492	50,388	51,375	52,334	52,899
90	43,468	44,585	45,568	46,462	47,444	48,391	49,321	50,214	51,197	52,153	52,716
95	43,322	44,435	45,415	46,206	47,285	48,229	49,155	50,046	51,025	51,978	52,539
100	43,181	44,281	45,267	46,155	47,131	48,072	48,995	49,883	50,859	51,809	52,368
105	43,045	44,151	45,124	46,009	46,982	47,920	48,840	49,697	50,699	51,616	52,203
110	42,914	44,016	44,987	45,869	46,839	47,774	48,691	49,574	50,544	51,488	52,043

TABLE NO. 11

WEIGHT OF DRY STEAM IN POUNDS PER MINUTE THAT WILL FLOW THROUGH PIPES OF GIVEN DIAMETER WITH LOSS OF ONE POUND OF PRESSURE

Steam Pressure above Vacuum.	Diameter of Pipe in Inches — Length of each Pipe = 240 Diameters.										
	¾	1	1½	2	2½	3	4	5	6	8	10
15	1.16	2.07	5.7	10.27	15.45	25.38	46.85	77.3	115.9	211.4	341.1
25	1.44	2.57	7.1	12.72	19.15	31.45	58.05	95.8	143.6	262.0	422.7
35	1.70	3.02	8.3	14.94	22.49	36.94	68.20	112.6	168.7	307.8	496.5
45	1.91	3.40	9.4	16.84	25.35	41.63	76.84	126.9	190.1	346.8	559.5
55	2.10	3.74	10.3	18.51	27.87	45.77	84.49	139.5	209.0	381.3	615.3
65	2.27	4.04	11.2	20.01	30.13	49.48	91.34	150.8	226.0	412.2	665.0
75	2.43	4.32	11.9	21.38	32.19	52.87	97.60	161.1	241.5	440.5	710.6
85	2.57	4.58	12.6	22.65	34.10	56.00	103.37	170.7	255.8	466.5	752.7
95	2.71	4.82	13.3	23.82	35.87	58.91	108.74	179.5	269.0	490.7	791.7
105	2.83	5.04	13.9	24.92	37.52	61.62	113.74	187.8	281.4	513.3	828.1
115	2.95	5.25	14.5	25.96	39.07	64.18	118.47	195.6	293.1	534.6	862.6
125	3.16	5.63	15.5	27.85	41.93	68.87	127.12	209.9	314.5	573.7	925.6

TABLE NO. 12

FLUE AREA REQUIRED FOR THE PASSAGE OF A GIVEN VOLUME OF AIR AT A GIVEN VELOCITY

Volume in Cubic Feet per Minute.	Velocity in Feet Per Minute.													
	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
100	48	36	29	24	21	18	16	14	13	12	11	10	9.6	9.
125	60	45	36	30	26	23	20	18	16	15	14	13	12.	11.3
150	72	54	43	36	31	27	24	22	20	18	16	15	14.4	13.5
175	84	63	50	42	36	32	28	25	23	21	19	18	16.8	15.8
200	96	72	58	48	41	36	32	29	26	24	22	21	19.2	18.
225	108	81	65	54	46	41	36	32	29	27	25	23	21.6	20.3
250	120	90	72	60	51	45	40	36	33	30	28	26	24.	22.5
275	132	99	79	66	57	50	44	40	36	33	30	28	26.4	24.8
300	144	108	86	72	62	54	48	43	39	36	33	31	28.8	27.
325	156	117	94	78	67	59	52	47	43	39	36	33	31.2	29.3
350	168	126	101	84	72	63	56	50	46	42	39	36	33.6	31.5
375	180	135	108	90	77	68	60	54	49	45	42	39	36.	33.8
400	192	144	115	96	82	72	64	58	52	48	44	41	38.4	36.
425	204	153	122	102	87	77	68	61	56	51	47	44	40.8	38.3
450	216	162	130	108	93	81	72	65	59	54	50	46	43.2	40.5
475	228	171	137	114	98	86	76	68	62	57	53	49	45.6	42.8
500	240	180	144	120	103	90	80	72	65	60	55	51	48.	45.
525	252	189	151	126	108	95	84	76	69	63	58	54	50.4	47.3
550	264	198	158	132	113	99	88	79	72	66	61	57	52.8	49.5
575	276	207	166	138	118	104	92	83	75	69	64	59	55.2	51.8
600	288	216	173	144	123	108	96	86	79	72	66	62	57.6	54.
625	300	225	180	150	129	113	100	90	82	75	69	64	60.	56.3
650	312	234	187	156	134	117	104	94	85	78	72	67	62.4	58.5
675	324	243	194	162	139	122	108	97	88	81	75	69	64.8	60.8
700	336	252	202	168	144	126	112	101	92	84	78	72	67.2	63.
725	348	261	209	174	149	131	116	104	95	87	80	75	69.6	65.3
750	360	270	216	180	154	135	120	108	98	90	83	77	72.	67.5
775	372	279	223	186	159	140	124	112	101	93	86	80	74.4	69.8
800	384	288	230	192	165	144	128	115	105	96	89	82	76.8	72.
825	396	297	238	198	170	149	132	119	108	99	91	85	79.2	74.3
850	408	306	245	204	175	153	136	122	111	102	94	87	81.6	76.5
875	420	315	252	210	180	158	140	126	115	105	97	90	84.	78.8
900	432	324	259	216	185	162	144	130	118	108	100	93	86.4	81.
925	444	333	266	222	190	167	148	133	121	111	103	95	88.8	83.3
950	456	342	274	228	195	171	152	137	124	114	105	98	91.2	85.5
975	468	351	281	234	201	176	156	140	128	117	108	100	93.6	87.8
1000	480	360	288	240	206	180	160	144	131	120	111	103	96.	90.

Continued on next page.

TABLE NO. 12 (*concluded*)

FLUE AREA REQUIRED FOR THE PASSAGE OF A GIVEN VOLUME OF AIR AT A GIVEN VELOCITY

Volume in Cubic Feet per Minute.	Velocity in Feet Per Minute.													
	1700	1800	1900	2000	2100	2200	2300	2400	2600	2700	2800	2900	3000	3100
100	8.5	8	7.6	7.2	6.9	6.6	6.3	6.	5.5	5.3	5.1	5.	4.8	4.6
125	10.6	10	9.5	9.	8.6	8.2	7.8	7.5	6.9	6.7	6.4	6.2	6.	5.8
150	12.7	12	11.4	10.8	10.3	9.8	9.4	9.	8.	8.	7.7	7.5	7.2	7.
175	14.8	14	13.3	12.6	12.	11.5	11.	10.5	9.7	9.3	9.	8.7	8.4	8.1
200	16.9	16	15.2	14.4	13.7	13.1	12.5	12.	11.1	10.7	10.3	9.9	9.6	9.3
225	19.1	18	17.1	16.2	15.6	14.7	14.1	13.5	12.5	12.	11,6	11.2	10.8	10.4
250	21.2	20	19.	18.	17.1	16.4	15.7	15.	13.9	13.3	12.9	12.4	12.	11.6
275	23.3	22	21.8	19.8	18.9	18.	17.2	16.5	15.2	14.7	14.1	13.7	13.2	12.8
300	25.4	24	22.7	21.6	20.6	19.6	18.8	18.	16.6	16.	15.4	14.9	14.4	13.9
325	27.5	26	24.6	23.4	22.3	21.3	20.6	19.5	18.	17.3	16.7	16.1	15.6	15.1
350	29.6	28	26.5	25.2	24.	22.9	21.9	21.	19.4	18.7	18.	17.4	16.8	16.3
375	31.8	30	28.4	27.	25.7	24.5	23.5	22.5	20.8	20.	19.3	18.6	18.	17.4
400	33.9	32	30.3	28.8	27.4	26.2	25.	24.	22.2	21.3	20.6	19.8	19.2	18.6
425	36.	34	32.2	30.6	29.1	27.8	26.6	25.5	23.5	22.7	21.9	21.1	20.4	19.7
450	38.1	36	34.1	32.4	30.9	29.5	28.2	27.	24.9	24.	23.1	22.3	21.6	20.9
475	40.2	38	36.	34.2	32.6	31.1	29.7	28.5	26.3	25.3	24.4	23.6	22.8	22.1
500	42.4	40	37.9	36.	34.3	32.7	31.3	30.	27.7	26.7	25.7	24.8	24.	23.2
525	44.5	42	39.8	37.8	36.	34.4	32.9	31.5	29.1	28.	26.9	25.	25.2	24.4
550	46.6	44	41.7	38.6	37.7	36.	34.4	33.	30.5	29.3	28.3	27.3	26.4	25.5
575	48.7	46	43.6	41.4	39.4	37.6	36.	34.5	31.9	30.7	29.6	28.5	27.6	26.7
600	50.8	48	45.5	43.2	41.1	39.3	37.6	36.	33.2	32.	30.8	29.8	28.8	27.8
625	52.9	50	47.4	45.	42.9	40.9	39.1	37.5	34.6	33.3	32.1	31.	30.	29.
650	55.1	52	49.3	46.8	44.6	42.5	40.7	39.	36.	34.7	33.4	32.2	31.2	30.2
675	57.2	54	51.2	48.6	46.3	44.1	42.3	40.5	37.5	36.	34.7	33.5	32.4	31.3
700	59.3	56	53.1	50.4	48.	45.8	43.8	42.	38.8	37.3	36.	34.7	33.6	32.5
725	61.4	58	55.	52.2	49.7	47.4	45.4	43.5	40.2	38.7	37.3	36.	34.8	33.6
750	63.5	60	56.9	54.	51.4	49.1	47.	45.	41.5	40.	38.6	37.2	36.	34.8
775	65.6	62	58.8	56.3	53.1	50.7	48.5	46.5	42.9	41.3	39.9	38.5	37.2	36.
800	67.8	64	60.6	57.6	54.9	52.4	50.1	48.	44.3	42.7	41.2	39.7	38.4	37.1
825	69.9	66	62.5	59.4	56.6	54.	51.7	49.5	45.7	44.	42.4	40.9	39.6	38.3
850	72.	68	64.4	61.2	58.4	55.6	53.2	51.	47.1	45.3	43.7	42.2	40.8	39.4
875	74.	70	67.3	63.	60.	57.3	54.8	52.5	48.5	46.7	45.	43.4	42.	40.6
900	76.2	72	68.2	64.8	61.7	58.9	56.3	54.	49.9	48.	46.3	44.6	43.2	41.8
925	78.4	74	70.1	66.6	63.4	60.5	57.9	55.5	51.3	49.3	47.6	46.	44.4	42.9
950	80.5	76	72.	68.4	65.1	62.2	59.5	57.	52.6	50.7	48.8	47.1	45.6	44.1
975	82.6	78	73.9	70.2	66.8	63.8	61.0	58.5	54.	52.	50.2	48.4	46.8	45.3
1000	84.7	80	75.8	72.	68.7	66.	62.6	60.	55.4	53.3	51.4	49.6	48.	46.4

TABLE NO. 13

Heat Units per Degree Difference of Temperature between the Entering Air and that of the Heating Surface for Different Velocities of Air Applicable in Forced Circulation

Velocity in Feet per Second	Velocity in Feet per Minute.	Gauge Reading Inches of Water.	B. T. U. per Degree Difference of Temperature per Square Foot per Hour.
1.0	60	0.002	2.0
2.5	150	0.014	3.13
5.0	300	0.064	4.5
7.5	450	0.124	5.5
10.0	600	0.22	6.33
12.5	750	0.37	7.1
15.0	900	0.50	7.75
17.5	1050	0.65	8.35
20.0	1200	0.82	9.0
22.5	1350	1.08	9.5
25.0	1500	1.28	10.0

TABLE NO. 14

NUMBER OF SQUARE INCHES OF FLUE AREA REQUIRED PER 1000 CUBIC FEET OF CONTENTS FOR GIVEN VELOCITY AND AIR CHANGE

No. Min. to change Air.	Velocity of Air in Flue in Feet per Minute.												
	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
4	120	90	72	60	51.6	45	40	36	32.2	30	27.6	25.6	21.4
5	96	72.2	57.6	48	41.1	36.1	32	28.8	26.2	24	22.2	20.5	19.2
6	80	60	48	40	34.3	30	26.6	24	21.8	20	18.5	17.1	16
7	68.6	51.4	41.1	34.3	29.4	25.7	22.9	20.6	18.7	17.2	15.7	14.7	13.7
8	60	45	36	30	25.8	22.5	20	18	16.1	15	13.8	12.8	12
9	53.3	40	32	26.6	22.9	20	17.8	16	14.5	13.3	12.3	11.4	10.7
10	48	36	28.8	24	20.6	18	16	14.4	13.1	12	11.1	10.3	9.6
11	43.6	32.2	26.2	21.8	18.7	16.1	14.5	13.1	11.9	10.9	10.1	9.5	8.7
12	40	30	24	20	17.2	15	13.3	12	10.9	10	9.2	8.6	8
13	36.9	27.7	22.2	18.5	15.7	13.8	12.3	11.1	10.1	9.2	8.5	7.9	7.4
14	34.3	25.7	20.6	17.2	14.7	12.8	11.4	10.3	9.5	8.6	7.9	7.4	6.9
15	32	24	19.2	16	13.7	12	10.7	9.6	8.7	8	7.4	6.9	6.4
16	30	22.5	18	15	12.9	11.2	10	9	8.2	7.5	6.9	6.4	6
17	28.2	21.2	16.9	14.1	12.1	10.6	9.4	8.5	7.7	7	6.5	6.1	5.6
18	26.6	20	16	13.3	11.5	10	8.9	8	7.3	6.6	6.2	5.7	5.3
19	25.3	18.9	15.2	12.6	10.8	9.5	8.4	7.6	6.9	6.3	5.8	5.4	5.1
20	24	18	14.4	12	10.3	9	8	7.2	6.5	6	5.5	5.1	4.8

TABLE NO. 15

HEIGHT OF WATER COLUMN IN INCHES, CORRESPONDING TO VARIOUS PRESSURES IN OUNCES PER SQUARE INCH

Pressure in Ounces per Square Inch.	Decimal Parts of an Ounce.									
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	. .	0.17	0.35	0.52	0.69	0.87	1.04	1.21	1.38	1.56
1	1.73	1.90	2.08	2.25	2.42	2.60	2.77	2.94	3.11	3.29
2	3.46	3.63	3.81	3.98	4.15	4.33	4.50	4.67	4.84	5.01
3	5.19	5.36	5.54	5.71	5.88	6.06	6.23	6.40	6.57	6.75
4	6.92	7.09	7.27	7.44	7.61	7.79	7.96	8.13	8.30	8.48
5	8.65	8.82	9.00	9.17	9.34	9.52	9.69	9.86	10.03	10.21
6	10.38	10.55	10.73	10.90	11.07	11.26	11.43	11.60	11.77	11.95
7	12.11	12.28	12.46	12.63	12.80	12.97	13.15	13.32	13.49	13.67
8	13.84	14.01	14.19	14.36	14.53	14.71	14.88	15.05	15.22	15.40
9	15.57	15.74	15.92	16.09	16.26	16.45	16.62	16.79	16.96	17.14

TABLE NO. 16

PRESSURE IN OUNCES PER SQUARE INCH, CORRESPONDING TO VARIOUS HEADS OF WATER IN INCHES

Head in Inches.	Decimal Parts of an Inch.									
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	. .	0.06	0.12	0.17	0.23	0.29	0.35	0.40	0.46	0.52
1	0.58	0.63	0.69	0.75	0.81	0.87	0.93	0.98	1.04	1.09
2	1.16	1.21	1.27	1.33	1.39	1.44	1.50	1.56	1.62	1.67
3	1.73	1.79	1.85	1.91	1.96	2.02	2.08	2.14	2.19	2.25
4	2.31	2.37	2.42	2.48	2.54	2.60	2.66	2.72	2.77	2.83
5	2.89	2.94	3.00	3.06	3.12	3.18	3.24	3.29	3.35	3.41
6	3.47	3.52	3.58	3.64	3.70	3.75	3.81	3.87	3.92	3.98
7	4.04	4.10	4.16	4.22	4.28	4.33	4.39	4.45	4.50	4.56
8	4.62	4.67	4.73	4.79	4.85	4.91	4.97	5.03	5.08	5.14
9	5.20	5.26	5.31	5.37	5.42	5.48	5.54	5.60	5.66	5.72

TABLE NO. 17

WEIGHT OF ROUND GALVANIZED STEEL PIPE AND ELBOWS, OF THE PROPER GAUGES FOR HEATING AND VENTILATING SYSTEMS

Gauge and Wt. per Sq. Foot.	Diam. of Pipe.	Area in Sq. Ins.	Weight per Running Foot.	Weight of Full Elbow.
No. 28 0.78	3	7.1	0.7	0.4
	4	12.6	1.1	0.9
	5	19.6	1.2	1.2
	6	28.3	1.4	1.7
	7	38.5	1.7	2.3
	8	50.3	1.9	2.9
No. 26 0.91	9	63.6	2.4	4.3
	10	78.5	2.7	5.3
	11	95.0	2.9	6.4
	12	113.1	3.2	7.6
	13	132.7	3.4	8.9
	14	153.9	3.7	10.4
No. 25 1.03	15	176.7	4.5	13.5
	16	201.1	4.7	15.1
	17	227.0	5.0	17.0
	18	254.5	5.3	19.1
	19	283.5	5.6	21.4
	20	314.2	6.0	23.9
No. 24 1.16	21	346.4	7.0	29.6
	22	380.1	7.3	32.3
	23	415.5	7.7	35.6
	24	452.4	8.0	38.6
	25	490.9	8.3	41.7
	26	530.9	8.7	45.1
No. 22 1.41	27	572.6	10.9	59.1
	28	615.7	11.4	64.2
	29	660.5	11.8	68.6
	30	706.9	12.2	73.4
	31	754.8	12.6	78.3
	32	804.3	13.0	83.4
	33	855.3	13.5	88.9
	34	907.9	13.9	94.3
	35	962.1	14.3	99.9
No. 20 1.66	36	1017.9	17.2	124.4
	37	1075.2	17.8	131.4
	38	1134.1	18.2	139.4
	39	1194.6	18.7	146.0
	40	1256.6	19.1	152.9
	41	1320.3	19.6	160.7
	42	1385.4	20.1	168.6
	43	1452.2	20.6	176.7
	44	1520.5	21.0	185.0
	45	1590.4	21.5	193.4
	46	1661.9	22.0	202.2
No. 18 2.16	47	1734.9	29.2	274.3
	48	1809.6	29.8	286.6
	49	1885.7	30.4	298.8
	50	1963.5	31.0	309.9
	51	2042.8	31.6	322.5
	52	2123.7	32.2	335.1
	53	2206.2	33.0	349.7
	54	2290.2	33.6	363.4
	55	2375.8	34.4	377.2
	56	2463.0	34.9	390.7
	57	2551.8	35.6	405.1
	58	2642.1	36.1	418.8
	59	2734.0	36.7	433.1
	60	2827.4	37.4	448.6
No. 16 2.66	61	2922.5	46.7	569.7
	62	3019.1	47.5	589.0
	63	3117.3	48.3	608.6
	64	3217.0	49.1	628.5
	65	3318.3	49.8	647.4
	66	3421.2	50.5	666.6
	67	3525.7	51.3	687.4
	68	3631.7	52.1	708.6
	69	3739.3	52.8	728.6
	70	3848.5	53.6	750.4
	71	3959.2	54.3	771.0
	72	4071.5	55.1	793.4

TABLE NO. 18

FACTORS FOR REDUCING THE WEIGHT OF GALVANIZED STEEL PIPE OF ONE GAUGE TO THAT OF ANOTHER GAUGE

Gauge.	GAUGE AND WEIGHT IN POUNDS PER SQUARE FOOT.																
	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	4.53	3.91	3.28	2.97	2.66	2.41	2.16	1.90	1.66	1.53	1.41	1.28	1.16	1.03	0.91	0.84	0.78
12	1.00	0.86	0.72	0.66	0.59	0.53	0.48	0.42	0.37	0.34	0.31	0.28	0.26	0.23	0.20	0.19	0.17
13	1.16	1.00	0.84	0.76	0.68	0.62	0.55	0.49	0.43	0.39	0.36	0.33	0.30	0.26	0.23	0.22	0.20
14	1.38	1.19	1.00	0.91	0.81	0.74	0.66	0.58	0.51	0.47	0.43	0.39	0.35	0.32	0.28	0.26	0.24
15	1.53	1.32	1.10	1.00	0.90	0.81	0.73	0.64	0.56	0.52	0.48	0.43	0.39	0.35	0.31	0.28	0.27
16	1.70	1.47	1.23	1.11	1.00	0.91	0.81	0.71	0.62	0.58	0.53	0.48	0.44	0.39	0.34	0.32	0.29
17	1.88	1.62	1.36	1.23	1.10	1.00	0.90	0.79	0.69	0.63	0.59	0.53	0.48	0.43	0.38	0.35	0.32
18	2.10	1.81	1.52	1.38	1.23	1.12	1.00	0.88	0.77	0.71	0.65	0.59	0.54	0.48	0.42	0.39	0.36
19	2.38	2.06	1.73	1.56	1.40	1.27	1.14	1.00	0.87	0.81	0.74	0.67	0.61	0.54	0.48	0.44	0.41
20	2.72	2.36	1.98	1.79	1.60	1.45	1.30	1.16	1.00	0.92	0.85	0 77	0.70	0.62	0.55	0.51	0.47
21	2.96	2.56	2.14	1.94	1.74	1.57	1.41	1.24	1.09	1.00	0.92	0.84	0.76	0.67	0.59	0.55	0.51
22	3.21	2.77	2.32	2.10	1.89	1.71	1.53	1.35	1.18	1.08	1.00	0.91	0.82	0.73	0.65	0.60	0.55
23	3.54	3.07	2.56	2.32	2.08	1.88	1.69	1.49	1.30	1.20	1.10	1.00	0.91	0.81	0.71	0.66	0.61
24	3.90	3.37	2.82	2.56	2.29	2.08	1.86	1.61	1.43	1.32	1.22	1.10	1.00	0.89	0.78	0.72	0.67
25	4.40	3.79	3.18	2.88	2.58	2.34	2.10	1.86	1.61	1.49	1.37	1.24	1.12	1.00	0.88	0.82	0.76
26	4.98	4.30	3.60	3.26	2.92	2.65	2.37	2.10	1.82	1.68	1.55	1.41	1.27	1.13	1.00	0.92	0.86
27	5.40	4.66	3.90	3.54	3.17	2.87	2.57	2.28	1.96	1.82	1.68	1.52	1.38	1.23	1.08	1.00	0.93
28	5.81	5.01	4.20	3.80	3.41	3.09	2.77	2.45	2.13	1.96	1.81	1.64	1.49	1.32	1.17	1.08	1.00

NOTE. — In table 17 the weights as given include the weight of rivets and solder, and due allowance has been made for laps and trimmings. The elbows have the internal radius equal to the diameter of the pipe. Rectangular pipes are usually made of the same gauge as round pipes of equivalent area.

The table above serves for the estimation of weights of pipe of gauges other than those given in table 17. Thus, suppose it is desired to find the weight of 28-inch pipe made of No. 16 gauge. From table 17, pipe of this size made of No. 20 gauge weighs 13.4 pounds per running foot. By the table above, the figure found at the junction of the column headed 16 and the line designated 20 is 1.60; therefore, the weight per foot of No. 16 gauge is 13.4 × 1.60 = 21.44 pounds.

TABLE NO. 19

AREAS OF CIRCLES AND LENGTHS OF THE SIDES OF SQUARES OF THE SAME AREA

Diam. of Circle in Inches.	Area of Circle in Square Inches.	Sides of Square of Same Area in Square Inches.	Diam. of Circle in Inches.	Area of Circle in Square Inches.	Sides of Square of Same Area in Square Inches.	Diam. of Circle in Inches.	Area of Circle in Square Inches.	Sides of Square of Same Area in Square Inches.
1.	.785	.89	21.	346.36	18.61	41.	1320.26	36.34
.½	1.767	1.33	.½	363.05	19.05	.½	1352.66	36.78
2.	3.142	1.77	22.	380.13	19.50	42.	1385.45	37.22
.½	4.909	2.22	.½	397.61	19.94	.½	1418.63	37.66
3.	7.069	2.66	23.	415.48	20.38	43.	1452.20	38.11
.½	9.621	3.10	.½	433.74	20.83	.½	1486.17	38.55
4.	12.566	3.54	24.	452.39	21.27	44.	1520.53	38.99
.½	15.904	3.99	.½	471.44	21.71	.½	1555.29	39.44
5.	19.635	4.43	25.	490.88	22.16	45.	1590.43	39.88
.½	23.758	4.87	.½	510.71	22.60	.½	1625.97	40.32
6.	28.274	5.32	26.	530.93	23.04	46.	1661.91	40.77
.½	33.183	5.76	.½	551.55	23.49	.½	1698.23	41.21
7.	38.485	6.20	27.	572.56	23.93	47.	1734.95	41.65
.½	44.179	6.65	.½	593.96	24.37	.½	1772.06	42.10
8.	50.266	7.09	28.	615.75	24.81	48.	1809.56	42.58
.½	56.745	7.53	.½	637.94	25.26	.½	1847.46	42.98
9.	63.617	7.98	29.	660.52	25.70	49.	1885.75	43.43
.½	70.882	8.42	.½	683.49	26.14	.½	1924.43	43.87
10.	78.540	8.86	30.	706.86	26.59	50.	1963.50	44.31
.½	86.590	9.30	.½	730.62	27.03	.½	2002.97	44.75
11.	95.03	9.75	31.	754.77	27.47	51.	2042.83	45.20
.½	103.87	10.19	.½	779.31	27.92	.½	2083.08	45.64
12.	113.10	10.63	32.	804.25	28.36	52.	2123.72	46.08
.½	122.72	11.08	.½	829.58	28.80	.½	2164.76	46.53
13.	132.73	11.52	33.	855.30	29.25	53.	2206.19	46.97
.½	143.14	11.96	.½	881.41	29.69	.½	2248.01	47.41
14.	153.94	12.41	34.	907.92	30.13	54.	2290.23	47.86
.½	165.13	12.85	.½	934.82	30.57	.½	2332.83	48.30
15.	176.72	13.29	35.	962.11	31.02	55.	2375.83	48.74
.½	188.69	13.74	.½	989.80	31.46	.½	2419.23	49.19
16.	201.06	14.18	36.	1017.88	31.90	56.	2463.01	49.63
.½	213.83	14.62	.½	1046.35	32.35	.½	2507.19	50.07
17.	226.98	15.07	37.	1075.21	32.79	57.	2551.76	50.51
.½	240.53	15.51	.½	1104.47	33.23	.½	2596.73	50.96
18.	254.47	15.95	38.	1134.12	33.68	58.	2642.09	51.40
.½	268.80	16.40	.½	1164.16	34.12	.½	2687.84	51.84
19.	283.53	16.84	39.	1194.59	34.56	59.	2733.98	52.29
.½	298.65	17.28	.½	1225.42	35.01	.½	2780.51	52.73
20.	314.16	17.72	40.	1256.64	35.45	60.	2827.74	53.17
.½	330.06	18.17	.½	1288.25	35.89	.½	2874.76	53.62

TABLE NO. 20

EQUATION OF PIPES

	1	2	3	4	5	6	7	8	9	10	12	14	16	18	20	24
2	5.7	1	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .	. .	. .	. .	. .	. .	. .
3	15.6	2.8	1	. . .	. . .	. . .	. . .	. . .	. . .	. .	. .	. .	. .	. .	. .	. .
4	32	5.7	2.1	1	. . .	. . .	. . .	. . .	. . .	. .	. .	. .	. .	. .	. .	. .
5	55.9	9.9	3.6	1.7	1	. . .	. . .	. . .	. . .	. .	. .	. .	. .	. .	. .	. .
6	88.2	15.6	5.7	2.8	1.6	1	. . .	. . .	. . .	. .	. .	. .	. .	. .	. .	. .
7	130	22.9	8.3	4.1	2.3	1.5	1	. . .	. . .	. .	. .	. .	. .	. .	. .	. .
8	181	32	11.7	5.7	3.2	2.1	1.4	1	. . .	. .	. .	. .	. .	. .	. .	. .
9	243	43	15.6	7.6	4.3	2.8	1.9	1.3	1	. .	. .	. .	. .	. .	. .	. .
10	316	55.9	20.3	9.9	5.7	3.6	2.4	1.7	1.3	1	. .	. .	. .	. .	. .	. .
11	401	70.9	25.7	12.5	7.2	4.6	3.1	2.2	1.7	1.3	. .	. .	. .	. .	. .	. .
12	499	88.2	32	15.6	8.9	5.7	3.8	2.8	2.1	1.6	1	. .	. .	. .	. .	. .
13	609	108	39.1	19	10.9	7.1	4.7	3.4	2.5	1.9	1.2	. .	. .	. .	. .	. .
14	733	130	47	22.9	13.1	8.3	5.7	4.1	3.0	2.3	1.5	1	. .	. .	. .	. .
15	871	154	55.9	27.2	15.6	9.9	6.7	4.8	3.6	2.8	1.7	1.2	. .	. .	. .	. .
16	. . .	181	65.7	32	18.3	11.7	7.9	5.7	4.2	3.2	2.1	1.4	1	. .	. .	. .
17	. . .	211	76.4	37.2	21.3	13.5	9.2	6.6	4.9	3.8	2.4	1.6	1.2	. .	. .	. .
18	. . .	243	88.2	43	24.6	15.6	10.6	7.6	5.7	4.3	2.8	1.9	1.3	1	. .	. .
19	. . .	278	101	49.1	28.1	17.8	12.1	8.7	6.5	5.0	3.2	2.1	1.5	1.1	. .	. .
20	. . .	316	115	55.9	32	20.3	13.8	9.9	7.4	5.7	3.6	2.4	1.7	1.3	1	. .
22	. . .	401	146	70.9	40.6	25.7	17.5	12.5	9.3	7.2	4.6	3.1	2.2	1.7	1.3	. .
24	. . .	499	181	88.2	50.5	32	21.8	15.6	11.6	8.9	5.7	3.8	2.8	2.1	1.6	1
26	. . .	609	221	108	61.7	39.1	26.6	19	14.2	10.9	7.1	4.7	3.4	2.5	1.9	1.2
28	. . .	733	266	130	74.2	47	32	22.9	17.1	13.1	8.3	5.7	4.1	3.0	2.3	1.5
30	. . .	871	316	154	88.2	55.9	38	27.2	20.3	15.6	9.9	6.7	4.8	3.6	2.8	1.7
36	. . .	. . .	499	243	130	88.2	60	43	32	24.6	15.6	10.6	7.6	5.7	4.3	2.8
42	. . .	. . .	733	357	205	130	88.2	63.2	47	36.2	19	15.6	11.2	8.3	6.4	4.1
48	. . .	. . .	. . .	499	286	181	123	88.2	62.7	50.5	32	21.8	15.6	11.6	8.9	5.7
54	. . .	. . .	. . .	670	383	243	165	118	88.2	67.8	43	29.2	20.9	15.6	12	7.6
60	. . .	. . .	. . .	871	499	316	215	154	115	88.2	55.9	38	27.2	20.3	15.6	9.9

TABLE NO. 21

RELATIVE HUMIDITY, GRAINS OF MOISTURE PER CUBIC FOOT, DEW POINT TEMPERATURES, WEIGHT OF SATURATED AIR PER CUBIC FOOT FOR DRY AND WET BULB TEMPERATURES OF THE SLING PSYCHROMETER.

30 INCHES MERCURY BAROMETER PRESSURE.

Air Temp.	Wt. cu. ft. Air saturated in pounds	Degrees Difference Between Dry Bulb and Wet Bulb Thermometers.																										
		Saturation.			1°			2°			3°			4°			5°			6°			7°			8°		
F°		%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point
0	.0861	100	0.48	0	67	0.32	−7	33	0.16	−20	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..
2	.0858	100	0.53	2	70	0.37	−5	39	0.21	−15	9	0.05	−40	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..
4	.0855	100	0.58	4	72	0.42	−2	44	0.26	−11	17	0.10	−28	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..
6	.0851	100	0.64	6	74	0.47	0	49	0.31	− 8	23	0.15	−21	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..
8	.0848	100	0.70	8	76	0.53	+3	53	0.37	− 5	29	0.20	−15	6	0.04	−42	..	...	..	..	...	..	..	...	..	..	...	..
10	.0845	100	0.78	10	78	0.61	5	56	0.44	− 2	34	0.26	−10	13	0.10	−27	..	...	..	..	...	..	..	...	..	..	...	..
12	.0841	100	0.86	12	80	0.69	7	59	0.50	+ 2	39	0.33	− 6	19	0.16	−19	..	...	..	..	...	..	..	...	..	..	...	..
14	.0838	100	0.94	14	81	0.76	10	62	0.58	5	44	0.41	− 2	26	0.24	−12	8	0.08	−33	..	...	..	..	...	..	..	...	..
16	.0835	100	1.03	16	82	0.85	12	65	0.67	7	48	0.49	+ 1	31	0.32	− 7	14	0.14	−20	..	...	..	..	...	..	..	...	..
18	.0831	100	1.13	18	84	0.95	14	68	0.77	10	52	0.59	5	36	0.41	− 2	20	0.23	−13	5	0.06	−37	..	...	..	..	...	..
20	.0828	100	1.23	20	85	1.05	16	70	0.86	12	55	0.68	8	40	0.49	+ 2	26	0.32	− 7	12	0.15	−21	..	...	..	..	...	..
22	.0824	100	1.35	22	86	1.16	19	71	0.96	15	58	0.78	11	44	0.59	5	31	0.42	− 2	17	0.23	−12	4	0.05	−36	..	...	..
24	.0821	100	1.48	24	87	1.29	21	73	1.08	17	60	0.89	13	47	0.70	9	35	0.52	+ 2	22	0.33	− 6	10	0.15	−20	..	...	..
26	.0818	100	1.62	26	87	1.41	23	75	1.22	20	63	1.02	16	51	0.83	12	39	0.63	7	27	0.44	− 1	16	0.26	−11	4	0.16	−32
28	.0814	100	1.77	28	88	1.56	25	76	1.35	22	65	1.15	19	54	0.96	15	43	0.76	10	32	0.57	+ 4	21	0.37	− 4	10	0.18	−17
30	.0811	100	1.93	30	89	1.72	27	78	1.51	25	67	1.29	21	56	1.08	18	46	0.89	14	36	0.70	8	26	0.50	+ 2	16	0.31	− 7
32	.0808	100	2.11	32	89	1.88	30	79	1.67	27	69	1.46	24	59	1.24	21	49	1.03	17	39	0.82	12	30	0.63	7	20	0.42	− 1
34	.0804	100	2.28	34	90	2.05	32	81	1.85	29	71	1.62	26	62	1.41	23	52	1.19	20	43	0.98	16	34	0.78	11	25	0.57	+ 5
36	.0801	100	2.46	36	91	2.24	34	82	2.02	31	73	1.80	29	64	1.57	26	55	1.35	23	46	1.13	19	38	0.93	15	29	0.71	10
38	.0797	100	2.65	38	91	2.41	36	83	2.20	33	75	1.99	31	66	1.75	28	58	1.54	25	50	1.32	22	42	1.11	18	33	0.87	14
40	.0794	100	2.85	40	92	2.62	38	83	2.36	35	75	2.14	33	68	1.94	30	60	1.71	28	52	1.48	25	45	1.28	21	37	1.05	18
42	.0790	100	3.06	42	92	2.82	40	85	2.60	38	77	2.36	35	69	2.11	33	62	1.90	30	55	1.68	27	47	1.44	24	40	1.22	21
44	.0787	100	3.29	44	93	3.06	42	85	2.80	40	78	2.57	37	71	2.34	35	63	2.07	32	56	1.84	30	49	1.61	27	43	1.42	24
46	.0784	100	3.54	46	93	3.29	44	86	3.04	42	79	2.80	40	72	2.54	37	65	2.30	35	58	2.05	32	52	1.84	29	45	1.59	27
48	.0780	100	3.80	48	93	3.53	46	86	3.27	44	79	3.00	42	73	2.77	40	66	2.51	37	60	2.28	35	54	2.05	32	47	1.79	29
50	.0777	100	4.08	50	93	3.79	48	87	3.55	46	80	3.26	44	74	3.02	42	67	2.73	40	61	2.49	37	55	2.24	34	49	2.00	32
52	.0774	100	4.37	52	94	4.11	50	87	3.80	48	81	3.54	46	75	3.28	44	69	3.02	42	63	2.75	40	57	2.49	37	51	2.23	34
54	.0771	100	4.69	54	94	4.41	52	88	4.13	50	82	3.85	48	76	3.56	46	70	3.28	44	64	3.00	42	59	2.77	40	53	2.48	37
56	.0767	100	5.02	56	94	4.72	54	88	4.42	53	82	4.12	51	76	3.82	49	71	3.56	47	65	3.26	44	60	3.01	42	55	2.76	40
58	.0764	100	5.37	58	94	5.05	56	88	4.73	55	83	4.46	53	77	4.13	51	72	3.87	49	66	3.54	47	61	3.28	45	56	3.01	42
60	.0761	100	5.75	60	94	5.41	58	89	5.12	57	83	4.77	55	78	4.48	53	73	4.20	51	68	3.91	49	63	3.62	47	58	3.34	45
62	.0757	100	6.14	62	94	5.77	60	89	5.46	59	84	5.16	57	79	4.85	55	74	4.54	53	69	4.24	52	64	3.93	50	59	3.62	47
64	.0754	100	6.56	64	95	6.23	62	90	5.90	61	84	5.51	57	79	5.15	57	74	4.85	56	70	4.59	54	65	4.26	52	60	3.94	50
66	.0751	100	7.01	66	95	6.66	64	90	6.31	63	85	5.96	61	80	5.61	60	75	5.26	58	71	4.98	56	66	4.63	54	61	4.28	52
68	.0748	100	7.48	68	95	7.12	67	90	6.73	65	85	6.36	63	80	5.98	62	76	5.68	60	71	5.31	58	67	5.01	57	62	4.64	55
70	.0744	100	7.98	70	95	7.58	69	90	7.18	67	86	6.86	65	81	6.46	64	77	6.14	62	72	5.75	61	68	5.43	59	64	5.12	57

Continued on next page.

TABLE NO. 21 (*Continued*)

RELATIVE HUMIDITY, GRAINS OF MOISTURE PER CUBIC FOOT, DEW POINT TEMPERATURES, WEIGHT OF SATURATED AIR PER CUBIC FOOT, FOR DRY AND WET BULB TEMPERATURES OF THE SLING PSYCHROMETER.

30 INCHES MERCURY BAROMETER PRESSURE.

Air Temp. F°	Wt. cu. ft. air saturated in pounds	Degrees Difference Between Dry Bulb and Wet Bulb Thermometers.																									
		Saturation.			1°			2°			3°			4°			5°			6°			7°			8°	
		%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point
70	.0744	100	7.98	70	95	7.58	69	90	7.18	67	86	6.86	65	81	6.46	64	77	6.14	62	72	5.75	61	68	5.43	59	64	5.11	57
71	.0743	100	8.24	71	95	7.83	70	90	7.42	68	86	7.09	67	81	6.67	65	77	6.34	63	72	5.93	62	68	5.60	60	64	5.27	58
72	.0741	100	8.51	72	95	8.08	71	91	7.74	69	86	7.32	68	82	6.98	66	77	6.55	64	73	6.21	63	69	5.87	61	65	5.53	59
73	.0739	100	8.78	73	95	8.34	72	91	7.99	70	86	7.55	69	82	7.20	67	78	6.85	66	73	6.41	64	69	6.06	62	65	5.71	60
74	.0738	100	9.07	74	95	8.62	73	91	8.25	71	86	7.80	70	82	7.44	68	78	7.07	67	74	6.71	65	69	6.26	63	65	5.90	62
75	.0736	100	9.36	75	96	8.99	74	91	8.52	72	86	8.05	71	82	7.68	69	78	7.30	68	74	6.93	66	70	6.55	64	66	6.18	63
76	.0734	100	9.66	76	96	9.27	75	91	8.79	73	87	8.40	72	82	7.92	70	78	7.53	69	74	7.15	67	70	6.76	66	66	6.38	64
77	.0733	100	9.96	77	96	9.56	76	91	9.06	74	87	8.67	73	83	8.27	71	79	7.87	70	74	7.37	68	71	7.07	67	67	6.67	65
78	.0731	100	10.28	78	96	9.87	77	91	9.35	75	87	8.94	74	83	8.53	72	79	8.12	71	75	7.71	69	71	7.30	68	67	6.89	66
79	.0729	100	10.60	79	96	10.18	78	91	9.65	76	87	9.22	75	83	8.80	73	79	8.37	72	75	7.95	70	71	7.53	69	68	7.21	67
80	.0728	100	10.93	80	96	10.49	79	91	9.95	77	87	9.51	76	83	9.07	74	79	8.63	73	75	8.20	72	72	7.87	70	68	7.43	68
81	.0726	100	11.28	81	96	10.83	80	92	10.38	78	88	9.93	77	84	9.48	75	80	9.02	74	76	8.57	73	72	8.12	71	69	7.78	70
82	.0724	100	11.63	82	96	11.16	81	92	10.70	79	88	10.23	78	84	9.77	77	80	9.30	75	76	8.84	74	72	8.37	72	69	8.02	71
83	.0723	100	11.99	83	96	11.51	82	92	11.03	80	88	10.55	79	84	10.07	78	80	9.59	76	76	9.11	75	73	8.75	73	69	8.27	72
84	.0721	100	12.36	84	96	11.87	83	92	11.37	81	88	10.88	80	84	10.38	79	80	9.89	77	76	9.39	76	73	9.02	74	69	8.53	73
85	.0719	100	12.74	85	96	12.23	84	92	11.72	82	88	11.21	81	84	10.70	80	81	10.32	78	77	9.81	77	73	9.30	75	70	8.92	74
86	.0718	100	13.13	86	96	12.60	85	92	12.07	83	88	11.55	82	84	11.03	81	81	10.64	79	77	10.11	78	73	9.58	76	70	9.19	75
87	.0716	100	13.53	87	96	12.99	86	92	12.45	84	88	11.91	83	85	11.50	82	81	10.96	80	77	10.42	79	74	10.01	78	70	9.47	76
88	.0714	100	13.94	88	96	13.38	87	92	12.82	85	88	12.27	84	85	11.85	83	81	11.29	81	77	10.73	80	74	10.32	79	70	9.76	77
89	.0713	100	14.36	89	96	13.79	88	92	13.21	86	88	12.64	85	85	12.21	84	81	11.63	82	78	11.20	81	74	10.63	80	71	10.20	78
90	.0711	100	14.79	90	96	14.20	89	92	13.61	87	89	13.16	86	85	12.57	85	81	11.98	83	78	11.54	82	74	10.94	81	71	10.50	79
91	.0709	100	15.23	91	96	14.62	90	92	14.01	88	89	13.55	87	85	12.95	86	82	12.49	85	78	11.87	83	75	11.42	82	72	10.97	80
92	.0708	100	15.69	92	96	15.06	91	92	14.43	89	89	13.96	88	85	13.34	87	82	12.87	86	78	12.24	84	75	11.76	83	72	11.30	81
93	.0706	100	16.16	93	96	15.51	92	93	15.03	90	89	14.38	89	85	13.74	88	82	13.25	87	78	12.60	85	75	12.12	84	72	11.64	83
94	.0704	100	16.63	94	96	15.96	93	93	15.47	92	89	14.80	90	85	14.14	89	82	13.64	88	79	13.14	86	75	12.47	85	72	11.97	84
95	.0702	100	17.12	95	96	16.44	94	93	15.92	93	89	15.24	91	86	14.72	90	82	14.04	89	79	13.52	87	76	13.01	86	73	12.50	85
96	.0701	100	17.63	96	96	16.92	95	93	16.40	94	89	15.69	92	86	15.16	91	82	14.46	90	79	13.93	88	76	13.40	87	73	12.87	86
97	.0699	100	18.14	97	96	17.41	96	93	16.87	95	89	16.14	93	86	15.60	92	83	15.06	91	79	14.33	89	76	13.79	88	73	13.24	87
98	.0697	100	18.67	98	96	17.92	97	93	17.36	96	89	16.62	94	86	16.05	93	83	15.50	92	79	14.75	90	76	14.19	89	73	13.63	88
99	.0695	100	19.21	99	96	18.44	98	93	17.87	97	89	17.10	95	86	16.51	94	83	15.99	93	80	15.37	92	76	14.60	90	73	14.02	89
100	.0694	100	19.77	100	96	18.98	99	93	18.39	98	89	17.60	96	86	17.00	95	83	16.41	94	80	15.82	93	77	15.22	91	73	14.43	90
102	.0690	100	20.92	102	96	20.08	101	93	19.46	100	90	18.83	98	86	17.99	97	83	17.36	96	80	16.74	95	77	16.11	93	74	15.48	92
104	.0686	100	22.13	104	97	21.47	103	93	20.58	102	90	19.92	100	87	19.26	99	83	18.37	98	80	17.70	97	77	17.04	95	74	16.38	94
106	.0682	100	23.39	106	97	22.69	105	93	21.75	104	90	21.05	102	87	20.35	101	84	19.65	100	81	18.95	99	78	18.24	98	75	17.54	96
108	.0678	100	24.72	108	97	23.98	107	93	22.99	106	90	22.25	104	87	21.51	103	84	20.76	102	81	20.02	101	78	19.28	100	75	18.54	98
110	.0674	100	26.11	110	97	25.83	109	93	24.28	108	90	23.50	106	87	22.72	105	84	21.93	104	81	21.12	103	78	20.37	102	75	19.58	100

Continued on next page.

TABLE NO. 21 (*Continued*)

RELATIVE HUMIDITY, GRAINS OF MOISTURE PER CUBIC FOOT, DEW POINT TEMPERATURES FOR DRY AND WET BULB TEMPERATURES OF THE SLING PSYCHROMETER.

30 INCHES MERCURY BAROMETER PRESSURE.

Air Temp.	Degrees Difference Between Dry Bulb and Wet Bulb Thermometers.																										
	9°			10°			11°			12°			13°			14°			15°			16°			17°		
F°	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point
30	6	0.12	−25	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..
32	11	0.23	−12	2	0.04	−42	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..
34	16	0.37	− 3	8	0.18	−17	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..
36	21	0.52	+ 3	13	0.32	− 6	5	0.12	−25	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..
38	25	0.66	8	17	0.45	+ 1	10	0.27	−10	2	0.05	−36	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..
40	29	0.83	13	22	0.63	7	15	0.43	− 1	7	0.20	−14	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..
42	33	1.01	17	26	0.80	12	19	0.58	+ 6	12	0.37	− 3	5	0.15	−18	..	...	..	..	...	..	..	...	..	..	...	..
44	36	1.18	20	30	0.99	16	23	0.76	11	16	0.53	+ 4	10	0.33	− 5	4	0.13	−24	..	...	..	..	...	..	..	...	..
46	39	1.38	23	32	1.13	20	26	0.92	15	20	0.71	10	14	0.50	+ 3	8	0.28	− 7	2	0.07	−30	..	...	..	..	...	..
48	41	1.56	26	35	1.33	23	29	1.10	19	23	0.87	14	18	0.68	9	12	0.46	+ 1	7	0.27	−10	1	0.04	−41	..	...	..
50	43	1.75	29	38	1.55	26	32	1.31	22	27	1.10	18	21	0.86	13	16	0.65	8	10	0.41	0	5	0.20	−13	..	...	..
52	46	2.01	32	40	1.75	29	35	1.53	26	29	1.27	22	24	1.05	18	19	0.83	13	14	0.61	+ 7	9	0.39	− 2	4	0.17	−17
54	48	2.25	34	42	1.97	32	37	1.74	29	32	1.50	25	27	1.27	22	22	1.03	18	17	0.80	12	12	0.56	+ 6	8	0.38	− 4
56	50	2.51	37	44	2.21	34	39	1.96	32	34	1.71	29	30	1.51	25	25	1.26	22	20	1.00	17	16	0.80	12	11	0.55	+ 5
58	51	2.74	40	46	2.47	37	41	2.20	35	37	1.99	32	32	1.72	29	27	1.45	25	23	1.24	21	18	0.97	17	14	0.75	11
60	53	3.05	43	48	2.76	40	43	2.47	38	39	2.24	35	34	1.96	32	30	1.73	29	26	1.50	25	21	1.21	21	17	0.98	17
62	54	3.32	45	50	3.07	43	45	2.76	40	41	2.52	38	36	2.21	35	32	1.96	32	28	1.72	29	24	1.47	25	20	1.23	21
64	56	3.67	48	51	3.35	46	47	3.08	43	43	2.82	41	38	2.49	38	34	2.23	35	30	1.97	32	26	1.71	29	22	1.44	25
66	57	4.00	50	53	3.72	48	48	3.36	46	44	3.08	44	40	2.80	41	36	2.52	38	32	2.24	35	29	2.03	32	25	1.75	29
68	58	4.34	53	54	4.04	51	50	3.74	49	46	3.44	46	42	3.14	44	38	2.84	42	34	2.54	39	31	2.32	36	27	2.02	33
70	59	4.71	55	55	4.39	53	51	4.07	51	48	3.83	49	44	3.51	47	40	3.19	44	36	2.87	42	33	2.63	39	29	2.31	36
71	60	4.94	56	56	4.61	54	52	4.28	52	48	3.96	50	45	3.71	48	41	3.38	46	37	3.05	43	33	2.72	41	30	2.47	38
72	61	5.19	58	57	4.85	56	53	4.51	54	49	4.17	52	45	3.83	50	42	3.57	47	38	3.23	45	34	2.89	42	31	2.64	40
73	61	5.36	59	57	5.01	57	53	4.65	55	50	4.39	53	46	4.04	51	42	3.69	49	39	3.43	46	35	3.07	44	32	2.81	41
74	61	5.53	60	58	5.26	58	54	4.90	56	50	4.54	54	47	4.26	52	43	3.90	50	39	3.54	48	36	3.27	45	33	2.99	43
75	62	5.80	61	58	5.43	59	54	5.05	57	51	4.77	55	47	4.40	54	44	4.12	51	40	3.74	49	37	3.46	47	34	3.18	44
76	62	5.99	62	59	5.70	60	55	5.31	59	51	4.93	57	48	4.64	55	44	4.25	53	41	3.96	51	38	3.67	48	34	3.28	46
77	63	6.27	63	59	5.88	62	56	5.58	60	52	5.18	58	48	4.78	56	45	4.48	54	42	4.18	52	39	3.88	50	35	3.49	48
78	63	6.48	64	60	6.17	63	56	5.76	61	53	5.45	59	49	5.04	57	46	4.73	55	43	4.42	53	39	4.01	51	36	3.70	49
79	64	6.78	66	60	6.36	64	57	6.04	62	53	5.62	60	50	5.30	59	46	4.88	57	43	4.56	55	40	4.24	53	37	3.92	50
80	64	7.00	67	61	6.67	65	57	6.23	63	54	5.90	62	50	5.47	60	47	5.14	58	44	4.81	56	41	4.48	54	38	4.15	52

Continued on next page.

TABLE NO. 21 (*Continued*)

RELATIVE HUMIDITY, GRAINS OF MOISTURE PER CUBIC FOOT, DEW POINT TEMPERATURES FOR DRY AND WET BULB TEMPERATURES OF THE SLING PSYCHROMETER.

30 INCHES MERCURY BAROMETER PRESSURE.

Air Temp.	Degrees Difference Between Dry Bulb and Wet Bulb Thermometers.																										
	9°			10°			11°			12°			13°			14°			15°			16°			17°		
F°	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point
80	64	7.00	67	61	6.67	65	57	6.23	63	54	5.90	62	50	5.47	60	47	5.14	58	44	4.81	56	41	4.48	54	38	4.15	52
81	65	7.33	68	61	6.88	66	58	6.54	65	55	6.20	63	51	5.75	61	48	5.41	59	45	5.08	57	42	4.74	55	38	4.34	53
82	65	7.56	69	61	7.09	67	58	6.75	66	55	6.40	64	51	5.93	62	48	5.58	60	45	5.23	59	42	4.88	57	39	4.54	55
83	66	7.91	70	62	7.43	69	59	7.07	67	56	6.71	65	52	6.23	64	49	5.88	62	46	5.52	60	43	5.16	58	40	4.77	56
84	66	8.16	71	62	7.66	70	59	7.19	68	56	6.92	66	52	6.33	65	49	6.06	63	46	5.69	61	43	5.31	59	40	4.94	57
85	66	8.41	72	63	8.03	71	60	7.64	69	57	7.26	68	53	6.75	66	50	6.37	64	47	5.99	62	44	5.61	61	41	5.22	59
86	66	8.67	73	63	8.27	72	60	7.88	70	57	7.48	69	53	6.96	67	50	6.57	65	47	6.17	64	44	5.78	62	42	5.51	60
87	67	9.07	75	64	8.66	73	61	8.25	72	57	7.71	70	54	7.31	68	51	6.90	67	48	6.49	65	45	6.09	63	42	5.68	61
88	67	9.34	76	64	8.92	74	61	8.50	73	57	7.95	71	54	7.53	69	51	7.11	68	48	6.69	66	46	6.41	64	43	5.99	62
89	68	9.76	77	65	9.33	75	61	8.76	74	58	8.33	72	55	7.90	71	52	7.47	69	49	7.04	67	47	6.75	66	44	6.32	64
90	68	10.06	78	65	9.61	76	61	9.02	75	58	8.58	73	55	8.13	72	52	7.69	70	49	7.25	69	47	6.95	67	44	6.51	65
91	68	10.36	79	65	9.90	78	62	9.44	76	59	8.99	75	56	8.53	73	52	7.92	71	49	7.46	70	47	7.16	68	44	6.70	66
92	68	10.67	80	65	10.20	79	62	9.73	77	59	9.26	76	56	8.79	74	53	8.32	73	50	7.85	71	48	7.53	69	45	7.06	68
93	68	10.99	81	66	10.67	80	62	10.02	78	60	9.70	77	56	9.05	75	54	8.73	74	51	8.24	72	49	7.92	71	46	7.38	69
94	69	11.47	82	66	10.97	81	63	10.47	79	60	9.98	78	57	9.48	76	54	8.98	75	51	8.48	73	49	8.15	72	46	7.65	70
95	69	11.81	83	66	11.30	82	63	10.79	80	60	10.27	79	58	9.93	78	54	9.24	76	51	8.73	74	49	8.39	73	46	7.88	71
96	69	12.16	84	66	11.64	83	63	11.11	82	61	10.75	80	58	10.23	79	55	9.70	77	52	9.17	76	50	8.82	74	47	8.25	72
97	69	12.52	85	66	11.97	84	64	11.62	83	61	11.07	81	58	10.52	80	55	9.98	78	53	9.61	77	50	9.07	75	48	8.71	74
98	70	13.07	87	67	12.51	85	64	11.95	84	61	11.39	82	58	10.83	81	56	10.46	79	53	9.90	78	50	9.34	76	48	8.96	75
99	70	13.45	88	67	12.87	86	65	12.49	85	61	11.72	83	59	11.33	82	56	10.76	81	53	10.18	79	51	9.80	78	48	9.22	76
100	70	13.84	89	68	13.44	87	65	12.85	86	62	12.26	85	59	11.66	83	56	11.07	82	54	10.68	80	51	10.08	79	49	9.69	77
102	71	14.85	91	68	14.23	89	65	13.60	88	62	12.97	87	60	12.55	85	57	11.92	84	55	11.51	83	52	10.88	81	49	10.25	80
104	71	15.71	93	69	15.27	92	66	14.61	90	63	13.94	89	60	13.28	88	58	12.83	86	55	12.17	85	53	11.73	83	50	11.07	82
106	72	16.84	95	69	16.14	94	66	15.44	92	64	14.97	91	61	14.27	90	58	13.56	88	56	13.09	87	53	12.39	86	51	11.92	84
108	72	17.80	97	70	17.30	96	67	16.56	95	64	15.82	93	62	15.33	92	59	14.58	91	57	14.09	89	54	13.35	88	52	12.85	86
110	73	19.06	99	70	18.28	98	67	17.49	97	65	16.97	95	62	16.19	94	60	15.67	93	57	14.88	91	55	14.36	90	52	13.58	89

Continued on next page.

TABLE NO. 21 (*Continued*)

RELATIVE HUMIDITY, GRAINS OF MOISTURE PER CUBIC FOOT, DEW POINT TEMPERATURES FOR DRY AND WET BULB TEMPERATURES OF THE SLING PSYCHROMETER.

30 INCHES MERCURY BAROMETER PRESSURE.

Air Temp.	Degrees Difference Between Dry Bulb and Wet Bulb Thermometers.																										
	18°			19°			20°			21°			22°			23°			24°			25°			26°		
F°	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point
54	3	0.14	−20	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..
56	7	0.35	− 5	2	0.10	−25	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..
58	10	0.54	+ 4	6	0.32	− 6	1	0.05	−30	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..
60	13	0.75	11	9	0.52	+ 4	5	0.29	− 8	1	0.06	−36	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..
62	16	0.98	16	12	0.74	11	8	0.49	+ 3	4	0.25	− 9	1	0.06	−45	..	...	..	..	...	..	..	...	..	..	...	..
64	18	1.18	21	15	0.98	17	11	0.72	11	7	0.46	+ 3	4	0.26	−10	..	...	..	..	...	..	..	...	..	..	...	..
66	21	1.47	26	17	1.19	22	14	0.98	17	10	0.70	11	7	0.49	+ 2	3	0.21	−11	..	...	..	..	...	..	..	...	..
68	23	1.72	29	20	1.50	26	16	1.20	22	13	0.97	17	10	0.75	11	6	0.45	+ 2	3	...	−11	..	...	..	..	...	..
70	25	2.00	33	22	1.76	30	19	1.52	26	15	1.20	22	12	0.96	17	9	0.72	11	6	0.48	+ 2	3	0.24	−11	..	...	..
71	27	2.22	35	23	1.90	31	20	1.65	28	17	1.40	24	13	1.07	20	10	0.82	14	7	0.58	7	4	0.33	− 3	..	...	..
72	28	2.39	37	24	2 04	33	21	1.79	30	18	1.53	26	15	1.28	22	12	1.02	17	9	0.77	11	6	0.51	+ 3	3	0.26	−11
73	29	2.55	38	25	2.20	35	22	1.93	32	19	1.67	28	16	1.40	25	13	1.14	20	10	0.88	15	7	0.61	8	4	0.35	− 3
74	29	2.63	40	26	2.36	37	23	2.09	34	20	1.81	30	17	1.54	27	14	1.27	23	11	1.00	18	8	0.73	12	5	0.45	+ 3
75	30	2.81	42	27	2.53	39	24	2.25	36	21	1.97	32	18	1:68	29	15	1.40	25	12	1.12	21	9	0.84	15	7	0.66	8
76	31	2.99	43	28	2.70	41	25	2.42	38	22	2.12	34	19	1.84	31	16	1.55	27	13	1.26	23	11	1.06	18	8	0.77	12
77	32	3.19	45	29	2.89	42	26	2.59	39	23	2.29	36	20	1.99	33	17	1.69	29	14	1.39	26	12	1.20	21	9	0.90	16
78	33	3.39	46	30	3.08	44	27	2.78	41	24	2.47	38	21	2.15	35	18	1.85	31	16	1.64	28	13	1.34	24	10	1.03	19
79	34	3.60	48	31	3.29	46	28	2.97	43	25	2.65	40	22	2.33	37	19	2.01	34	17	1.80	30	14	1.48	26	11	1.17	22
80	35	3.83	50	32	3.50	47	29	3.17	44	26	2.84	42	23	2.51	39	20	2.19	36	18	1.97	32	15	1.64	28	12	1.31	24
81	35	3.95	51	33	3.72	49	29	3.27	46	26	2.93	43	24	2.71	41	21	2.37	38	19	2.14	34	16	1.80	31	14	1.58	27
82	36	4.19	52	33	3.84	50	30	3.49	48	28	3.26	45	25	2.91	42	22	2.56	39	20	2.33	36	17	1.98	33	14	1.63	29
83	37	4.43	54	34	4.08	52	31	3.72	49	29	3.48	47	26	3.12	44	23	2.76	41	20	2.40	38	18	2.16	35	15	1.80	31
84	37	4.57	55	35	4.33	53	32	3.96	51	29	3.58	48	26	3.21	46	24	2.97	43	21	2.60	40	19	2.35	37	16	1.98	34
85	38	4.84	57	35	4.46	54	32	4.07	52	30	3.81	50	28	3.57	48	25	3.19	45	22	2.80	42	20	2.55	39	17	2.17	36

Continued on next page.

TABLE NO. 21 (*Continued*)

RELATIVE HUMIDITY, GRAINS OF MOISTURE PER CUBIC FOOT, DEW POINT TEMPERATURES FOR DRY AND WET BULB TEMPERATURES OF THE SLING PSYCHROMETER.

30 INCHES MERCURY BAROMETER PRESSURE.

Air Temp.	Degrees Difference Between Dry Bulb and Wet Bulb Thermometers.																										
	18°			19°			20°			21°			22°			23°			24°			25°			26°		
F°	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point
85	38	4.84	57	35	4.46	54	32	4.07	52	30	3.81	50	28	3.57	48	25	3.19	45	22	2.80	42	20	2.55	39	17	2.17	36
86	39	5.12	58	36	4.73	56	33	4.33	54	31	4.07	52	28	3.68	49	26	3.41	47	23	3.02	44	21	2.76	41	18	2.36	38
87	39	5.28	59	36	4.87	57	34	4.60	55	31	4.19	53	29	3.92	51	26	3.52	48	24	3.25	46	22	2.98	43	19	2.57	40
88	40	5.58	61	37	5.16	59	35	4.88	57	32	4.46	55	30	4.18	52	27	3.76	50	25	3.46	47	22	3.07	45	20	2.79	42
89	41	5.89	62	38	5.46	60	35	5.03	58	33	4.74	56	31	4.45	54	28	4.07	51	25	3.59	49	23	3.30	46	21	3.02	44
90	41	6.06	63	39	5.76	61	36	5.32	59	34	5.03	57	31	4.58	55	29	4.29	53	26	3.85	51	24	3.55	48	22	3.25	45
91	42	6.40	65	40	6.09	63	37	5.64	61	34	5.18	59	32	4.87	57	30	4.57	55	27	4.12	52	25	3.81	50	22	3.35	47
92	42	6.59	66	40	6.28	64	37	5.81	62	35	5.49	60	32	5.02	58	30	4.71	56	28	4.39	54	25	3.92	51	23	3.61	49
93	43	6.95	67	40	6.46	65	37	5.98	63	36	5.82	62	33	5.33	60	31	5.01	58	28	4.52	55	26	4.20	53	24	3.88	51
94	43	7.15	68	41	6.82	67	38	6.32	65	36	5.99	63	33	5.49	61	31	5.16	59	29	4.82	57	27	4.49	55	24	3.99	52
95	44	7.53	70	42	7.19	68	39	6.68	66	36	6.16	64	34	5.82	62	31	5.31	60	29	4.96	58	27	4.62	56	25	4.28	54
96	44	7.76	71	42	7.40	69	39	6.87	67	37	6.52	66	35	6.17	64	32	5.64	62	30	5.29	60	28	4.94	58	26	4.58	55
97	45	8.16	72	42	7.62	70	40	7.26	69	38	6.89	67	35	6.35	65	33	5.99	63	31	5.62	61	29	5.26	59	27	4.90	57
98	45	8.40	73	43	8.03	72	40	7.47	70	38	7.09	68	36	6.72	66	34	6.35	64	32	5.97	63	29	5.41	61	27	5.04	58
99	45	8.64	74	44	8.45	73	41	7.88	71	38	7.30	69	36	6.92	68	34	6.53	66	32	6.15	64	30	5.76	62	28	5.38	60
100	46	9.09	76	44	8.70	74	41	8.11	72	39	7.71	71	37	7.31	69	35	6.92	67	33	6.52	65	30	5.93	63	28	5.54	61
102	47	9.83	78	45	9.41	76	42	8.79	75	40	8.37	73	38	7.95	72	36	7.53	70	34	7.11	68	32	6.69	65	30	6.28	64
104	48	10.61	80	46	10.18	79	43	9.52	77	41	9.07	76	39	8.63	74	37	8.19	72	35	7.75	71	33	7.30	66	31	6.86	67
106	49	11.46	83	46	10.76	81	44	10.29	80	42	9.82	78	40	9.36	77	38	8.89	75	36	8.42	73	34	7.95	68	32	7.48	70
108	49	12.11	85	47	11.62	84	45	11.12	82	43	10.63	81	41	10.14	79	39	9.64	77	37	9.15	76	35	8.65	69	33	8.16	72
110	50	13.06	87	48	12.53	86	46	12.01	84	44	11.49	83	42	10.97	81	40	10.44	80	38	9.92	78	36	9.40	70	34	8.89	75

Continued on next page.

TABLE NO. 21 (*Concluded*)

RELATIVE HUMIDITY, GRAINS OF MOISTURE PER CUBIC FOOT, DEW POINT TEMPERATURES FOR DRY AND WET BULB TEMPERATURES OF THE SLING PSYCHROMETER.

30 INCHES MERCURY BAROMETER PRESSURE.

Air Temp.	Degrees Difference Between Dry Bulb and Wet Bulb Thermometers.																										
	27°			28°			29°			30°			31°			32°			33°			34°			35°		
F°	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew point	%	Grs. moist.	Dew poin
75	4	0.37	− 2	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..
76	5	0.48	+ 4	3	0.29	−10	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..
77	6	0.60	9	4	0.40	− 2	1	0.10	−21	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..
78	8	0.82	13	5	0.51	+ 5	2	0.21	− 9	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..
79	9	0.95	16	6	0.64	10	4	0.42	− 1	1	0.11	−20	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..
80	10	1.09	20	7	0.77	13	5	0.55	+ 6	3	0.33	− 7	..	...	..	..	...	..	..	...	..	..	...	..	..	...	..
81	11	1.24	22	9	1.02	17	6	0.68	10	4	0.45	0	1	0.11	−18	..	...	..	..	...	..	..	...	..	..	...	..
82	12	1.40	25	10	1.16	20	7	0.81	14	5	0.58	+ 7	2	0.23	− 6	..	...	..	..	...	..	..	...	..	..	...	..
83	13	1.56	27	11	1.32	23	8	0.96	18	6	0.72	11	4	0.48	+ 2	2	0.24	−15	..	...	..	..	...	..	..	...	..
84	14	1.73	30	12	1.48	26	9	1.11	21	7	0.87	15	5	0.62	8	3	0.37	− 4	..	...	..	..	...	..	..	...	..
85	15	1.91	32	13	1.66	28	10	1.27	24	8	1.02	19	6	0.76	12	4	0.51	+ 3	2	0.25	−12	..	...	..	..	...	..
86	16	2.10	34	14	1.84	31	11	1.44	27	9	1.18	22	7	0.92	16	5	0.66	9	3	0.39	− 2	1	0.13	−27	..	...	..
87	17	2.30	36	15	2.03	33	12	1.62	29	10	1.35	25	8	1.08	20	6	0.81	13	4	0.54	+ 5	2	0.27	−10	..	...	..
88	18	2.57	38	15	2.09	35	13	1.81	31	11	1.53	27	9	1.26	23	7	0.98	17	5	0.70	10	3	0.42	0	1	0.14	−22
89	19	2.73	41	16	2.30	37	14	2.01	34	12	1.72	30	10	1.44	26	8	1.15	21	6	0.86	15	4	0.57	+ 6	2	0.28	− 7
90	19	2.81	43	17	2.51	39	15	2.22	36	13	1.92	32	11	1.63	28	9	1.33	24	7	1.04	19	5	0.74	11	3	0.44	+ 1
91	20	3.05	44	18	2.74	41	16	2.44	38	14	2.13	35	12	1.83	31	10	1.52	27	8	1.22	22	6	0.91	16	4	0.61	8
92	21	3.30	46	19	2.98	43	17	2.67	40	15	2.35	37	13	2.04	33	11	1.73	29	9	1.41	25	7	1.10	20	5	0.78	13
93	22	3.56	48	19	3.07	45	17	2.75	42	15	2.42	39	13	2.10	36	12	1.94	32	10	1.62	28	8	1.29	23	6	0.97	17
94	22	3.66	50	20	3.33	47	18	3.00	44	16	2.66	41	14	2.33	38	12	2.00	34	10	1.66	30	9	1.50	26	7	1.16	21
95	23	3.94	52	21	3.60	49	19	3.25	46	17	2.91	43	15	2.57	40	13	2.23	37	11	1.88	33	9	1.54	29	8	1.37	24
96	24	4.23	53	22	3.88	51	20	3.53	48	18	3.17	45	16	2.82	42	14	2.47	39	12	2.12	35	10	1.76	31	8	1.41	27
97	25	4.54	55	22	3.99	52	20	3.63	50	18	3.27	47	16	2.90	44	15	2.72	41	13	2.36	38	11	2.00	34	9	1.63	30
98	25	4.67	56	23	4.30	54	21	3.92	52	19	3.55	49	17	3.17	46	15	2.80	43	14	2.61	40	12	2.24	36	10	1.87	32
99	26	5.00	58	24	4.61	56	22	4.23	53	20	3.84	51	18	3.46	48	16	3.07	45	14	2.69	42	13	2.50	39	11	2.11	35
100	26	5.14	59	24	4.75	57	22	4.35	55	21	4.15	52	19	3.76	50	17	3.36	47	15	2.97	44	13	2.57	41	12	2.37	37
102	28	5.86	62	26	5.44	60	24	5.02	58	22	4.60	56	20	4.18	53	18	3.77	51	16	3.35	48	15	3.14	45	13	2.72	42
104	29	6.42	65	27	5.98	63	25	5.53	61	23	5.09	59	21	4.65	57	20	4.43	54	18	3.98	52	16	3.54	49	14	3.10	46
106	30	7.02	68	28	6.55	66	26	6.08	64	24	5.61	62	23	5.38	60	21	4.91	58	19	4.45	55	17	3.98	53	16	3.74	50
108	31	7.66	71	29	7.17	69	27	6.67	67	25	6.18	65	24	5.93	63	22	5.44	61	20	4.94	59	19	4.70	56	17	4.20	54
110	32	8.36	73	30	7.83	72	28	7.31	70	26	6.79	68	25	6.53	66	23	6.01	64	21	5.48	62	20	5.22	60	18	4.70	57

TABLE NO. 22

HEATING INSTALLATION DATA FOR MULTIVANE FANS

¼-INCH STATIC PRESSURE (WATER GAUGE) AIR AT 65° F.

ORDINARY RESISTANCE FOR PUBLIC BUILDING VENTILATION WITHOUT HEATERS. SYSTEMS WELL PROPORTIONED.

Size Fan.	R. P. M.	Vol. Cu. Ft. per Min.	Brake H. P.	Size Motor.	Size Vertical Engine.			Size Horizontal Engine.			Size Pulley.	
					80 lbs. Pres.	100 lbs. Pres.	120 lbs. Pres.	80 lbs. Pres.	100 lbs. Pres.	120 lbs. Pres.	Dia. in.	Face in.
2	503	513	.04	2 B	3×2½	3×2½	3×2½	. . .	. . .	. . .	6	3½
	523	617	.05	2 B	"	"	"	. . .	. . .	. . .	"	"
	558	756	.07	2 B	"	"	"	. . .	. . .	. . .	"	"
	617	935	.11	1 B	"	"	"	. . .	. . .	. . .	"	"
3	402	802	.06	1 H	3×2½	3×2½	3×2½	. . .	. . .	. . .	7	4
	418	963	.08	1 H	"	"	"	. . .	. . .	. . .	"	"
	446	1180	.11	1 H	"	"	"	. . .	. . .	. . .	"	"
	492	1460	.17	2 B	"	"	"	. . .	. . .	. . .	"	"
4	334	1160	.09	1 C	3×2½	3×2½	3×2½	. . .	. . .	. . .	8	5
	347	1392	.12	1 C	"	"	"	. . .	. . .	. . .	"	"
	371	1710	.16	1 H	"	"	"	. . .	. . .	. . .	"	"
	409	2110	.25	1 H	"	"	"	. . .	. . .	. . .	"	"
5	287	1565	.13	1 C	3×2½	3×2½	3×2½	. . .	. . .	. . .	10	5
	298	1880	.16	1 C	"	"	"	. . .	. . .	. . .	"	"
	318	2305	.22	1 C	"	"	"	. . .	. . .	. . .	"	"
	351	2855	.34	1 C	"	"	"	. . .	. . .	. . .	"	"
6	251	2050	.17	1 C	3×2½	3×2½	3×2½	. . .	. . .	. . .	12	6
	261	2470	.21	1 C	"	"	"	. . .	. . .	. . .	"	"
	278	3030	.29	1 C	"	"	"	. . .	. . .	. . .	"	"
	308	3750	.45	1 C	"	"	"	. . .	. . .	. . .	"	"
6½	224	2620	.21	1 C	3×2½	3×2½	3×2½	. . .	. . .	. . .	13	6½
	233	3150	.26	1 C	"	"	"	. . .	. . .	. . .	"	"
	248	3870	.37	1 C	"	"	"	. . .	. . .	. . .	"	"
	274	4790	.58	1 C	"	"	"	. . .	. . .	. . .	"	"
7	201	3210	.26	1 C	3×2½	3×2½	3×2½	. . .	. . .	. . .	14	7½
	209	3850	.32	1 C	"	"	"	. . .	. . .	. . .	"	"
	223	4730	.45	1 C	"	"	"	. . .	. . .	. . .	"	"
	246	5850	.70	1 C	"	"	"	. . .	. . .	. . .	"	"
8	167	4650	.38	1 C	3×2½	3½×2½	3×2½	. . .	. . .	. . .	16	9
	174	5580	.47	1 C	"	"	"	. . .	. . .	. . .	"	"
	186	6850	.65	1 C	3½×3	"	"	. . .	. . .	. . .	"	"
	205	8480	1.00	1 C	"	"	"	. . .	. . .	. . .	"	"
9	144	6300	.51	1½ C	3½×3	3½×2½	3½×2½	. . .	. . .	. . .	18	10½
	149	7550	.64	1½ C	"	"	"	. . .	. . .	. . .	"	"
	159	9270	.89	1½ C	4×4	3½×3	"	. . .	. . .	. . .	"	"
	176	11450	1.4	1 C	5×5	4×4	4×4	. . .	. . .	. . .	"	"
10	125	8270	.67	1½ C	4×4	3½×3	3½×2½	. . .	. . .	. . .	20	10½
	130	9920	.84	1½ C	5×5	4×4	"	. . .	. . .	. . .	"	"
	139	12150	1.2	2 C	"	"	4×4	. . .	. . .	. . .	"	"
	154	15050	1.8	2 C	"	5×5	"	. . .	. . .	. . .	"	"
11	111	10370	.84	2 C	5×5	4×4	3×3½	. . .	. . .	. . .	22	12
	116	12460	1.00	2 C	"	5×5	4×4	. . .	. . .	. . .	"	"
	123	15300	1.5	2 C	"	"	5×5	. . .	. . .	. . .	"	"
	136	18920	2.3	2 C	"	"	"	. . .	. . .	. . .	"	"

Continued on next page.

TABLE NO. 22 (*Continued*)

HEATING INSTALLATION DATA FOR MULTIVANE FANS

¼-INCH STATIC PRESSURE (WATER GAUGE) AIR AT 65° F.

ORDINARY RESISTANCE FOR PUBLIC BUILDING VENTILATION WITHOUT HEATERS. SYSTEMS WELL PROPORTIONED.

Size Fan.	R. P. M.	Vol. Cu. Ft. per Min.	Brake H. P.	Size Motor.	Size Vertical Engine.			Size Horizontal Engine.			Size Pulley.	
					80 lbs. Pres.	100 lbs. Pres.	120 lbs. Pres.	80 lbs. Pres.	100 lbs. Pres.	120 lbs. Pres.	Dia. in.	Face in.
12	100	12820	1.00	2 C	5×5	5×5	4×4	. . .	. . .	. . .	24	12
	105	15400	1.3	2 C	"	"	5×5	. . .	. . .	. . .	"	"
	111	18900	1.8	3 C	6×5	6×5	"	. . .	. . .	. . .	"	"
	123	23400	2.8	3 C	7×5	"	"	. . .	. . .	. . .	"	"
13	91	15560	1.3	3 C	5×5	5×5	5×5	. . .	. . .	. . .	28	13½
	95	18700	1.6	4 C	"	"	"	. . .	. . .	. . .	"	"
	101	22920	2.2	4 C	6×5	"	"	. . .	. . .	. . .	"	"
	112	28380	3.4	4 C	7×5	6×5	6×5	. . .	. . .	. . .	"	"
14	84	18600	1.5	4 C	6×5	5×5	5×5	. . .	. . .	. . .	32	13½
	87	22350	1.9	4 C	"	6×5	"	. . .	. . .	. . .	"	"
	93	27400	2.6	4 C	7×5	"	6×5	. . .	. . .	. . .	"	"
	103	33900	4.1	4 C	7×6	7×5	6×6	. . .	. . .	. . .	"	"
15	77	21800	1.8	4 C	6×5	6×5	5×5	. . .	. . .	. . .	36	14½
	80	26200	2.2	5 C	7×5	"	"	. . .	. . .	. . .	"	"
	86	32150	3.1	5 C	7×6	7×5	6×5	. . .	. . .	. . .	"	"
	95	39750	4.8	5 C	8×6	7×6	7×6	. . .	. . .	. . .	"	"
16	72	25200	2.0	6 C	7×5	6×5	6×5	. . .	. . .	. . .	42	14½
	75	30250	2.5	6 C	7×6	7×5	"	. . .	. . .	. . .	"	"
	80	37100	3.5	6 C	8×6	7×6	6×6	. . .	. . .	. . .	"	"
	88	45900	5.5	10 C	8×8	8×6	7×6	. . .	. . .	. . .	"	"
17	67	28950	2.3	. . .	7×6	6×6	6×5	. . .	. . .	. . .	48	14½
	70	34800	2.9	. . .	8×6	7×6	6×6	. . .	. . .	. . .	"	"
	74	42750	4.1	24 C	8×7	8×6	7×6	. . .	. . .	. . .	"	"
	82	52800	6.4	15 C	9×8	8×7	7×7	8×10	. . .	. . .	"	"
18	63	32900	2.7	. . .	8×6	7×5	7×6	. . .	. . .	. . .	. .	. .
	65	39500	3.3	. . .	"	8×6	"	. . .	. . .	. . .	. .	. .
	70	48400	4.6	. . .	9×7	"	7×7	. . .	. . .	. . .	. .	. .
	77	59900	7.2	24 C	10×8	9×8	8×7	10×10	8×10	. . .	. .	. .
20	56	41500	3.4	. . .	9×7	8×7	7×6	. . .	. . .	. . .	. .	. .
	58	49800	4.2	. . .	"	"	7×7	8×10	. . .	. . .	. .	. .
	62	61200	5.9	. . .	10×8	9×7	8×8	"	8×10	. . .	. .	. .
	68	75600	9.1	. . .	11×9	10×8	9×8	11×10	10×10	8×10	. .	. .
22	50	51300	4.2	. . .	9×8	9×7	8×7	8×10	8×10	8×10	. .	. .
	52	61700	5.2	. . .	10×8	9×8	8×8	10×10	"	"	. .	. .
	56	75600	7.2	. . .	11×9	10×8	9×8	"	10×10	"	. .	. .
	62	93500	11.3	. . .	12×10	11×9	10×9	12×12	11×10	10×10	. .	. .
24	46	62000	5.0	. . .	10×9	9×8	8×8	. . .	. . .	. . .	. .	. .
	48	74600	6.3	. . .	11×9	10×8	9×8	. . .	. . .	. . .	. .	. .
	51	91500	8.8	. . .	12×10	11×9	10×9	12×12	11×10	10×10	. .	. .
	56	113000	13.6	. . .	"	12×10	11×10	13×12	12×12	10×12	. .	. .
26	42	73800	6.0	. . .	11×9	11×9	9×9	. . .	. . .	. . .	. .	. .
	44	88750	7.5	. . .	12×10	12×10	10×9	. . .	. . .	. . .	. .	. .
	46	108900	10.4	. . .	. . . .	12×10	10×10	. . .	. . .	. . .	. .	. .
	51	134800	16.2	. . .	. . . .	. . . .	. . . .	14×14	13×12	12×12	. .	. .

Continued on next page.

TABLE NO. 22 (*Continued*)

HEATING INSTALLATION DATA FOR MULTIVANE FANS

½-INCH STATIC PRESSURE (WATER GAUGE) AIR AT 65° F.

MAXIMUM RESISTANCE FOR PUBLIC BUILDING VENTILATION WITH COMPLEX SYSTEMS AND WITHOUT HEATERS.
MINIMUM RESISTANCE FOR PUBLIC BUILDING HEATING WITHOUT AIR WASHERS.

Size Fan.	R. P. M.	Vol. Cu. Ft. per Min.	Brake H. P.	Size Motor.	Size Vertical Engine.			Size Horizontal Engine.			Size Pulley.	
					80 lbs. Pres.	100 lbs. Pres.	120 lbs. Pres.	80 lbs. Pres.	100 lbs. Pres.	120 lbs. Pres.	Dia. in.	Face in.
2	714	725	.12	1 B	3×2½	3×2½	3×2½	. . .	. . .	. . .	6	3½
	740	873	.15	1 B	"	"	"	. . .	. . .	. . .	"	"
	789	1070	.20	1 B	"	"	"	. . .	. . .	. . .	"	"
	872	1325	.32	1 B	. . .	. . .	. . .	. . .	. . .	. . .	"	"
3	570	1135	.18	1 B	3×2½	3×2½	3×2½	. . .	. . .	. . .	7	4
	591	1362	.23	1 B	"	"	"	. . .	. . .	. . .	"	"
	630	1670	.32	1 B	"	"	"	. . .	. . .	. . .	"	"
	697	2068	.50	1 B	"	"	"	. . .	. . .	. . .	"	"
4	473	1640	.27	2 B	3×2½	3×2½	3×2½	. . .	. . .	. . .	8	5
	492	1970	.33	2 B	"	"	"	. . .	. . .	. . .	"	"
	523	2415	.46	2 B	"	"	"	. . .	. . .	. . .	"	"
	579	3000	.72	2 B	"	"	"	. . .	. . .	. . .	"	"
5	406	2215	.36	1 H	3×2½	3×2½	3×2½	. . .	. . .	. . .	10	5
	422	2660	.45	1 H	"	"	"	. . .	. . .	. . .	"	"
	449	3260	.63	1 H	"	"	"	. . .	. . .	. . .	"	"
	497	4040	.98	1 H	"	"	"	. . .	. . .	. . .	"	"
6	356	2910	.47	1 C	3×2½	3×2½	3×2½	. . .	. . .	. . .	12	6
	369	3500	.59	2 H	"	"	"	. . .	. . .	. . .	"	"
	393	4285	.82	2 H	"	"	"	. . .	. . .	. . .	"	"
	435	5310	1.3	2 H	"	"	"	. . .	. . .	. . .	"	"
6½	318	3710	.60	1 C	3×2½	3×2½	3×2½	. . .	. . .	. . .	13	6½
	330	4460	.75	1 C	"	"	"	. . .	. . .	. . .	"	"
	351	5470	1.0	1 C	"	"	"	. . .	. . .	. . .	"	"
	388	6770	1.6	3 H	3½×3	"	"	. . .	. . .	. . .	"	"
7	285	4540	.74	1 C	3½×3	3×2½	3×2½	. . .	. . .	. . .	14	7½
	295	5450	.92	1 C	"	"	"	. . .	. . .	. . .	"	"
	315	6680	1.3	1 C	4×4	3½×3	"	. . .	. . .	. . .	"	"
	348	8280	2.0	1 C	"	4×4	3½×3	. . .	. . .	. . .	"	"
8	237	6580	1.1	1 C	4×4	3½×3	3½×3	. . .	. . .	. . .	16	9
	246	7900	1.3	1 C	"	"	"	. . .	. . .	. . .	"	"
	262	9700	1.9	1 C	"	4×4	4×4	. . .	. . .	. . .	"	"
	290	12000	2.9	1 C	5×5	5×5	5×5	. . .	. . .	. . .	"	"
9	203	8900	1.4	1½ C	5×5	4×4	3½×3	. . .	. . .	. . .	18	10½
	211	10700	1.8	1½ C	"	"	4×4	. . .	. . .	. . .	"	"
	225	13100	2.5	1½ C	"	5×5	"	. . .	. . .	. . .	"	"
	248	16250	3.9	2 C	6×5	"	5×5	. . .	. . .	. . .	"	"
10	175	11700	1.9	2 C	5×5	5×5	4×4	. . .	. . .	. . .	20	10½
	182	14000	2.4	2 C	"	"	5×5	. . .	. . .	. . .	"	"
	194	17200	3.3	3 C	6×5	"	"	. . .	. . .	. . .	"	"
	214	21300	5.2	4 C	7×5	6×5	"	. . .	. . .	. . .	"	"
11	158	14700	2.4	3 C	6×5	5×5	5×5	. . .	. . .	. . .	22	12
	164	17600	3.0	4 C	"	"	"	. . .	. . .	. . .	"	"
	175	21600	4.1	4 C	7×5	6×5	"	. . .	. . .	. . .	"	"
	193	26800	6.5	4 C	7×6	7×5	6×5	. . .	. . .	. . .	"	"

Continued on next page.

TABLE NO. 22 (*Continued*)
HEATING INSTALLATION DATA FOR MULTIVANE FANS

½-INCH STATIC PRESSURE (WATER GAUGE) AIR AT 65° F.

MAXIMUM RESISTANCE FOR PUBLIC BUILDING VENTILATION WITH COMPLEX SYSTEMS AND WITHOUT HEATERS.
MINIMUM RESISTANCE FOR PUBLIC BUILDING HEATING WITHOUT AIR WASHERS.

Size Fan.	R. P. M.	Vol. Cu. Ft. per Min.	Brake H. P.	Size Motor.	Size Vertical Engine.			Size Horizontal Engine.			Size Pulley.	
					80 lbs. Pres.	100 lbs. Pres.	120 lbs. Pres.	80 lbs. Pres.	100 lbs. Pres.	120 lbs. Pres.	Dia. in.	Face in.
12	142	18150	2.9	4 C	6×5	5×5	5×5	...	...	...	24	12
	148	21800	3.7	4 C	7×5	6×5	"	...	...	...	"	"
	157	26750	5.1	5 C	7×6	7×5	6×5	...	...	...	"	"
	174	33100	8.0	6 C	8×6	7×6	6×6	...	...	...	"	"
13	129	22000	3.6	4 C	7×5	6×5	6×5	...	...	...	28	13½
	134	26450	4.5	5 C	7×6	7×5	"	...	...	...	"	"
	143	32400	6.2	6 C	8×6	7×6	6×6	...	...	...	"	"
	158	40200	9.7	8 C	9×7	8×6	7×6	...	...	...	"	"
14	119	26300	4.3	5 C	7×6	7×5	6×6	...	...	...	32	13½
	123	31600	5.3	6 C	8×6	7×6	"	...	...	...	"	"
	131	38750	7.4	8 C	8×7	8×6	7×6	...	...	...	"	"
	145	48000	11.6	10 C	9×8	8×7	7×7	8×10	...	...	"	"
15	110	30800	5.0	8 C	8×6	7×6	7×6	...	...	...	36	14½
	114	37050	6.3	8 C	8×7	8×6	"	...	...	...	"	"
	121	45400	8.7	8 C	9×7	8×7	7×7	8×10	...	...	"	"
	134	56300	13.6	12½ C	10×8	9×8	8×8	10×10	8×10	...	"	"
16	102	36650	5.8	8 C	8×7	8×6	7×6	...	...	...	42	14½
	105	42800	7.2	10 C	9×7	8×7	7×7	8×10	...	...	"	"
	112	52500	10.	15 C	10×8	9×7	8×7	10×10	8×10	...	"	"
	124	65000	15.7	15 C	11×9	10×8	9×8	"	10×10	8×10	"	"
17	95	41000	6.7	10 C	9×7	8×7	7×7	8×10	...	...	48	14½
	99	49200	8.3	15 C	9×8	9×7	8×7	"	...	...	"	"
	105	60300	11.5	15 C	10×9	9×8	8×8	10×10	8×10	8×10	"	"
	116	74800	18.0	19 C	11×10	10×9	9×9	11×10	10×10	10×10	"	"
18	89	46500	7.5	15 C	10×8	9×7	8×7	8×10	...	...	...	...
	92	55800	9.4	19 C	10×9	9×8	8×8	10×10	8×10	...	...	...
	98	68500	13.1	19 C	11×9	10×8	9×8	11×10	10×10	8×10	...	...
	109	85000	20.5	19 C	12×10	11×9	10×9	12×12	11×10	10×10	...	...
20	79	58750	9.5	24 C	11×9	10×8	9×8	10×10	10×10	8×10	...	...
	82	70500	11.9	24 C	11×10	10×9	9×9	11×10	"	10×10	...	...
	88	86500	16.5	24 C	12×10	11×10	10×9	12×12	11×10	"	...	...
	97	107000	25.9	34 C	....	12×10	11×10	14×14	12×12	12×12	...	...
22	71	72700	11.8	24 C	12×10	11×9	10×9	12×12	10×10	10×10	...	...
	74	87300	14.7	29 C	12×10	11×10	10×10	"	11×10	"	...	...
	79	106800	20.5	34 C	....	12×10	11×10	13×12	12×12	10×12	...	...
	87	132500	32.0	...	....	....	....	16×14	14×12	12×12	...	...
24	65	88000	14.2	...	12×10	12×10	11×10	12×12	12×12	10×12	...	...
	67	105300	17.8	...	....	12×10	11×10	14×12	"	12×12	...	...
	72	129200	24.8	...	....	....	....	"	13×12	13×12	...	...
	79	160000	38.7	...	....	....	....	16×14	14×16	14×14	...	...
26	59	104500	17.0	...	....	....	....	14×12	12×12	12×12	...	...
	61	125300	21.2	...	....	....	....	14×14	13×12	"	...	...
	66	153700	29.5	...	....	....	....	16×14	14×14	14×14	...	...
	73	190100	46.0	...	....	....	....	18×16	16×16	14×16	...	...

Continued on next page.

TABLE NO. 22 (*Continued*)

HEATING INSTALLATION DATA FOR MULTIVANE FANS

¾-INCH STATIC PRESSURE (WATER GAUGE) AIR AT 65° F.

ORDINARY RESISTANCE FOR PUBLIC BUILDING HEATING SYSTEMS.

Size Fan.	R. P. M.	Vol. Cu. Ft. per Min.	Brake H. P.	Size Motor.	Size Vertical Engine.			Size Horizontal Engine.			Size Pulley.	
					80 lbs. Pres.	100 lbs. Pres.	120 lbs. Pres.	80 lbs. Pres.	100 lbs. Pres.	120 lbs. Pres.	Dia. in.	Face in.
2	872	888	.22	1 B	....	....	....	...	...	...	6	3½
	906	1070	.27	1 B	....	....	....	...	...	...	"	"
	966	1310	.37	1 B	....	....	....	...	...	...	"	"
	1068	1620	.59	1 B	....	....	....	...	...	...	"	"
3	697	1387	.34	1 B	3×2½	3×2½	3×2½	...	...	...	7	4
	724	1670	.42	1 B	"	"	"	...	...	...	"	"
	772	2044	.58	1 B	"	"	"	...	...	...	"	"
	853	2533	.92	2 B	....	....	....	...	...	...	"	"
4	578	2000	.49	2 B	3×2½	3×2½	3×2½	...	...	...	8	5
	602	2420	.61	2 B	"	"	"	...	...	...	"	"
	642	2960	.85	1 H	"	"	"	...	...	...	"	"
	709	3670	1.3	1 H	"	"	"	...	...	...	"	"
5	496	2710	.66	1 H	3×2½	3×2½	3×2½	...	...	...	10	5
	516	3260	.83	1 H	"	"	"	...	...	...	"	"
	550	4000	1.1	1 H	"	"	"	...	...	...	"	"
	608	4950	1.8	2 H	3½×3	"	"	...	...	...	"	"
6	435	3560	.87	1 H	3×2½	3×2½	3×2½	...	...	...	12	6
	453	4280	1.1	2 H	"	"	"	...	...	...	"	"
	482	5250	1.5	2 H	3½×3	"	"	...	...	...	"	"
	533	6500	2.4	3 H	4×4	"	"	...	...	...	"	"
6½	388	4540	1.1	2 H	3½×3	3×2½	3×2½	...	...	...	13	6½
	404	5470	1.4	2 H	"	"	"	...	...	...	"	"
	430	6700	1.9	3 H	4×4	3½×3	"	...	...	...	"	"
	476	8300	3.0	3 H	"	4×4	3½×3	...	...	...	"	"
7	348	5550	1.4	1 C	3½×3	3½×3	3×2½	...	...	...	14	7½
	362	6680	1.7	1 C	4×4	"	3½×3	...	...	...	"	"
	386	8180	2.3	1 C	"	4×4	"	...	...	...	"	"
	426	10140	3.7	5 C	5×5	"	4×4	...	...	...	"	"
8	290	8050	2.0	1 C	4×4	4×4	4×4	...	...	...	16	9
	302	9690	2.5	1½ C	5×5	"	"	...	...	...	"	"
	322	11850	3.4	2 C	"	5×5	"	...	...	...	"	"
	355	14700	5.3	2 C	"	"	5×5	...	...	...	"	"
9	249	10900	2.6	2 C	5×5	5×5	4×4	...	...	...	18	10½
	259	13100	3.3	2 C	6×5	"	5×5	...	...	...	"	"
	276	16050	4.6	2 C	"	"	"	...	...	...	"	"
	305	19900	7.2	4 C	7×5	6×5	"	...	...	...	"	"
10	217	14300	3.5	3 C	6×5	5×5	5×5	...	...	...	20	10½
	226	17200	4.4	3 C	"	"	"	...	...	...	"	"
	241	21050	6.0	4 C	7×5	6×5	"	...	...	...	"	"
	266	26100	9.5	6 C	7×6	7×5	6×5	...	...	...	"	"
11	193	17960	4.4	4 C	7×5	6×5	5×5	...	...	...	22	11
	201	21600	5.5	4 C	"	"	6×5	...	...	...	"	"
	214	26500	7.6	5 C	7×6	7×5	"	...	...	...	"	"
	236	32800	11.9	8 C	8×7	7×6	7×6	...	...	...	"	"

Continued on next page.

TABLE NO. 22 (*Continued*)

HEATING INSTALLATION DATA FOR MULTIVANE FANS

¾-INCH STATIC PRESSURE (WATER GAUGE) AIR AT 65° F.

ORDINARY RESISTANCE FOR PUBLIC BUILDING HEATING SYSTEMS.

Size Fan.	R. P. M.	Vol. Cu. Ft. per Min.	Brake H. P.	Size Motor.	Size Vertical Engine.			Size Horizontal Engine.			Size Pulley.	
					80 lbs. Pres.	100 lbs. Pres.	120 lbs. Pres.	80 lbs. Pres.	100 lbs. Pres.	120 lbs. Pres.	Dia. in.	Face in.
12	174	22200	5.4	5 C	7×5	7×5	6×5	. . .	. . .	. . .	24	12
	181	26750	6.8	6 C	7×6	"	6×6	. . .	. . .	. . .	"	"
	193	32750	9.4	6 C	8×6	7×6	7×6	. . .	. . .	. . .	"	"
	213	40600	14.7	10 C	9×7	8×7	7×7	8×10	. . .	. . .	"	"
13	158	26950	6.5	6 C	7×7	7×6	6×6	. . .	. . .	. . .	28	13½
	165	32400	8.2	8 C	8×7	7×6	7×6	. . .	. . .	. . .	"	"
	175	39700	11.3	10 C	9×7	8×6	7×7	. . .	. . .	. . .	"	"
	194	49200	17.8	15 C	10×8	9×7	8×7	10×10	8×10	. . .	"	"
14	145	32200	7.8	8 C	8×7	8×6	7×6	. . .	. . .	. . .	32	13½
	151	38800	9.8	10 C	9×7	"	7×7	8×10	. . .	. . .	"	"
	161	47450	13.6	15 C	9×8	9×7	8×7	10×10	. . .	. . .	"	"
	178	58800	21.3	15 C	10×9	10×8	9×8	"	10×10	8×10	"	"
15	134	37700	9.2	12½ C	9×7	8×7	7×7	8×10	. . .	. . .	36	14½
	139	45450	11.5	15 C	9×8	9×7	8×7	"	. . .	. . .	"	"
	148	55600	15.9	15 C	10×9	9×8	8×8	10×10	8×10	8×10	"	"
	164	69000	24.9	15 C	11×10	10×10	9×9	11×10	10×10	10×10	"	"
16	124	43600	10.6	12½ C	9×9	9×7	8×7	10×10	. . .	. . .	42	14½
	129	52500	13.3	15 C	10×8	9×8	8×8	"	8×10	8×10	"	"
	138	64300	18.4	15 C	11×9	10×8	9×8	11×10	10×10	"	"	"
	152	79600	28.8	19 C	12×10	11×10	10×9	12×12	11×10	10×10	"	"
17	116	50200	12.2	15 C	10×9	9×8	8×8	10×10	8×10	8×10	48	14½
	121	60300	15.3	19 C	10×10	10×8	9×8	"	10×10	"	"	"
	129	73900	21.1	19 C	11×10	10×10	10×9	12×12	"	10×10	"	"
	142	91600	33.1	24 C	. . . .	12×10	11×10	13×12	12×12	10×12	"	"
18	109	56850	13.8	15 C	11×9	10×9	9×9	10×10	10×10	8×10	. .	. .
	113	68500	17.4	19 C	11×10	"	"	11×10	"	10×10	. .	. .
	121	83800	24.0	24 C	. . . .	11×10	10×10	12×12	11×10	"	. .	. .
	133	103800	37.6	34 C	. . . .	. . . .	. . . .	14×12	12×12	12×12	. .	. .
20	97	71800	17.5	24 C	12×10	11×9	10×9	12×12	11×10	10×10	. .	. .
	101	86500	21.9	29 C	. . . .	12×10	10×10	"	12×12	10×12	. .	. .
	107	105700	30.3	. . .	. . . .	. . . .	. . . .	14×12	"	12×12	. .	. .
	119	131200	47.5	. . .	. . . .	. . . .	. . . .	16×14	14×12	12×14	. .	. .
22	87	88800	21.6	34 C	. . . .	12×10	11×10	13×12	12×12	10×12	. .	. .
	91	106900	27.1	. . .	. . . .	. . . .	. . . .	14×12	"	12×12	. .	. .
	97	131000	37.5	. . .	. . . .	. . . .	. . . .	14×16	14×12	12×14	. .	. .
	107	162100	58.7	. . .	. . . .	. . . .	. . . .	16×16	16×14	14×14	. .	. .
24	79	107300	26.1	. . .	. . . .	. . . .	. . . .	14×14	12×12	12×12	. .	. .
	82	129200	32.8	. . .	. . . .	. . . .	. . . .	14×16	14×12	12×14	. .	. .
	88	158200	45.3	. . .	. . . .	. . . .	. . . .	16×16	16×14	14×14	. .	. .
	97	196100	71.0	. . .	. . . .	. . . .	. . . .	. . .	18×16	16×16	. .	. .
26	72	127800	31.0	. . .	. . . .	. . . .	. . . .	16×14	14×14	12×14	. .	. .
	75	153700	39.0	. . .	. . . .	. . . .	. . . .	16×16	14×16	14×14	. .	. .
	80	188200	53.8	. . .	. . . .	. . . .	. . . .	18×16	16×16	14×16	. .	. .
	89	233200	84.5	. . .	. . . .	. . . .	. . . .	. . .	. . .	. . .	. .	. .

Continued on next page.

TABLE NO. 22 (*Continued*)

HEATING INSTALLATION DATA FOR MULTIVANE FANS

1-INCH STATIC PRESSURE (WATER GAUGE) AIR AT 65° F.

MAXIMUM RESISTANCE FOR PUBLIC BUILDING HEATING SYSTEMS WITH AIR WASHERS. MINIMUM RESISTANCE FOR FACTORY HEATING SYSTEMS.

Size Fan.	R. P. M.	Vol. Cu. Ft. per Min.	Brake H. P.	Size Motor.	Size Vertical Engine.			Size Horizontal Engine.			Size Pulley.	
					80 lbs. Pres.	100 lbs. Pres.	120 lbs. Pres.	80 lbs. Pres.	100 lbs. Pres.	120 lbs. Pres.	Dia. in.	Face in.
2	1007	1025	.33	1 B	....	....	....	...	...	...	6	3½
	1047	1235	.42	1 B	....	....	....	...	...	...	"	"
	1115	1510	.58	1 B	....	....	....	...	...	...	"	"
	1230	1870	.90	1 B	....	....	....	...	...	...	"	"
3	804	1600	.52	1 B	3×2½	3×2½	3×2½	...	...	...	7	4
	836	1930	.65	1 B	"	"	"	...	...	...	"	"
	892	2360	.90	2 B	"	"	"	...	...	...	"	"
	984	2920	1.4	1 H	"	"	"	...	...	...	"	"
4	668	2320	.75	2 B	3×2½	3×2½	3×2½	...	...	...	8	5
	695	2790	.95	1 H	"	"	"	...	...	...	"	"
	741	3420	1.3	1 H	"	"	"	...	...	...	"	"
	818	4230	2.0	1 H	"	"	"	...	...	...	"	"
5	573	3130	1.0	1 H	3×2½	3×2½	3×2½	...	...	...	10	5
	597	3770	1.3	2 H	"	"	"	...	...	...	"	"
	636	4670	1.8	2 H	"	"	"	...	...	...	"	"
	702	5710	2.8	2 H	"	"	"	...	...	...	"	"
6	502	4110	1.3	2 H	3½×3	3×2½	3×2½	...	...	...	12	6
	522	4950	1.7	2 H	"	"	"	...	...	...	"	"
	557	6050	2.3	3 H	"	3½×2½	"	...	...	...	"	"
	615	7500	3.6	4 H	4×4	4×4	3½×3	...	...	...	"	"
6½	448	5250	1.7	3 H	3½×3	3½×3	3×2½	...	...	...	13	6½
	466	6320	2.1	3 H	4×4	"	"	...	...	...	"	"
	497	6740	3.0	4 H	"	4×4	3½×3	...	...	...	"	"
	549	9570	4.6	4 H	....	"	4×4	...	...	...	"	"
7	402	6410	2.1	4 H	4×4	3½×3	3½×3	...	...	...	14	7½
	418	7720	2.6	5 H	"	4×4	"	...	...	...	"	"
	445	9460	3.6	5 H	5×5	"	4×4	...	...	...	"	"
	492	11800	5.6	6 H	"	5×5	"	...	...	...	"	"
8	335	9300	3.0	1½ C	5×5	4×4	4×4	...	...	...	16	9
	348	11200	3.8	2 C	"	5×5	"	...	...	...	"	"
	371	13700	5.2	2 C	"	"	5×5	...	...	...	"	"
	410	16950	8.2	3 C	6×5	"	"	...	...	...	"	"
9	287	12580	4.1	2 C	5×5	5×5	5×5	...	...	...	18	10½
	298	15150	5.1	3 C	6×5	"	"	...	...	...	"	"
	318	18550	7.1	4 C	"	6×5	"	...	...	...	"	"
	352	22950	11.1	4 C	7×6	7×5	6×5	...	...	...	"	"
10	251	16500	5.4	3 C	6×5	6×5	5×5	...	...	...	20	10½
	261	19880	6.7	4 C	7×5	"	"	...	...	...	"	"
	278	24320	9.3	6 C	7×6	7×5	6×5	...	...	...	"	"
	308	30100	14.5	8 C	8×6	7×6	6×6	...	...	...	"	"
11	223	20750	6.7	5 C	7×6	6×5	6×5	...	...	...	22	12
	231	25000	8.5	6 C	"	7×5	"	...	...	...	"	"
	247	30600	11.7	8 C	8×6	7×6	6×6	...	...	...	"	"
	272	37850	18.2	8 C	9×7	8×7	7×7	8×10	...	...	"	"

Continued on next page.

TABLE NO. 22 (*Continued*)

HEATING INSTALLATION DATA FOR MULTIVANE FANS

1-INCH STATIC PRESSURE (WATER GAUGE) AIR AT 65° F.

MAXIMUM RESISTANCE FOR PUBLIC BUILDING HEATING SYSTEMS WITH AIR WASHERS. MINIMUM RESISTANCE FOR FACTORY HEATING SYSTEMS.

Size Fan.	R. P. M.	Vol. Cu. Ft. per Min.	Brake H. P.	Size Motor.	Size Vertical Engine.			Size Horizontal Engine.			Size Pulley.	
					80 lbs. Pres.	100 lbs. Pres.	120 lbs. Pres.	80 lbs. Pres.	100 lbs Pres.	120 lbs. Pres.	Dia. in.	Face in.
12	201	25600	8.3	6 C	8×6	7×5	6×6	. . .	. . .	. . .	24	12
	209	30900	10.5	8 C	8×7	7×6	7×6	. . .	. . .	. . .	"	"
	223	37800	14.4	10 C	9×7	8×6	7×7	. . .	. . .	. . .	"	"
	246	46800	22.6	12½ C	10×8	9×7	8×7	10×10	8×10	. . .	"	"
13	183	31050	10.1	10 C	8×7	8×6	7×6	. . .	. . .	. . .	28	13½
	190	37450	12.7	10 C	9×7	8×7	7×7	. . .	. . .	. . .	"	"
	202	45850	17.5	12½ C	10×8	9×7	8×7	10×10	8×10	. . .	"	"
	223	56750	27.4	15 C	10×9	10×8	9×8	"	10×10	8×10	"	"
14	168	37100	12.0	10 C	9×8	8×7	7×7	8×10	. . .	. . .	32	13½
	174	44750	15.2	12½ C	10×8	9×7	8×7	10×10	8×10	. . .	"	"
	186	54800	21.0	15 C	10×9	10×8	9×8	"	"	8×10	"	"
	205	67850	32.7	19 C	11×10	10×10	10×9	10×12	10×10	10×10	"	"
15	155	43600	14.1	15 C	10×8	9×7	8×7	10×10	8×10	. . .	36	14½
	161	52500	17.8	15 C	10×9	9×8	9×8	"	"	8×10	"	"
	171	64250	24.6	19 C	11×10	10×9	9×9	11×10	10×10	10×10	"	"
	189	79500	38.3	24 C	. . . .	11×10	10×10	12×12	11×10	"	"	"
16	143	50300	16.3	15 C	10×9	9×9	9×8	10×10	10×10	8×10	42	14½
	149	60700	20.5	19 C	11×9	10×8	"	11×10	"	"	"	"
	159	74250	28.4	24 C	12×10	11×9	10×9	12×12	10×12	10×10	"	"
	176	91800	44.3	29 C	. . . .	12×10	11×10	13×12	12×12	10×12	"	"
17	134	57850	18.8	19 C	11×10	10×8	9×9	11×10	10×10	10×10	48	14½
	140	69800	23.6	24 C	12×10	10×10	10×9	12×12	"	"	"	"
	149	85400	32.6	24 C	. . . .	12×10	10×10	"	12×12	10×12	"	"
	164	105200	51.0	34 C	. . . .	. . . .	. . . .	14×14	12×14	12×12	"	"
18	126	65600	21.3	24 C	12×10	10×10	10×9	12×12	10×10	10×10	. .	. .
	131	79000	26.8	29 C	. . . .	11×10	10×10	"	11×10	"	. .	. .
	139	96800	37.0	34 C	. . . .	12×10	11×10	14×12	12×12	12×12	. .	. .
	154	119800	57.8	. . .	. . . .	. . . .	. . . .	14×16	14×12	"	. .	. .
20	112	82900	26.9	29 C	. . . .	12×10	11×10	12×14	12×12	10×12	. .	. .
	116	100000	33.8	. . .	. . . .	. . . .	. . . .	14×12	"	12×12	. .	. .
	124	122000	46.8	. . .	. . . .	. . . .	. . . .	14×16	14×12	"	. .	. .
	137	151100	73.0	. . .	. . . .	. . . .	. . . .	16×16	14×16	14×14	. .	. .
22	100	102500	33.3	. . .	. . . .	. . . .	. . . .	14×14	12×14	12×12	. .	. .
	105	123500	41.8	. . .	. . . .	. . . .	. . . .	16×14	14×12	12×14	. .	. .
	111	151000	57.8	. . .	. . . .	. . . .	. . . .	16×16	14×16	14×14	. .	. .
	123	187000	90.2	. . .	. . . .	. . . .	. . . .	. . .	16×16	16×16	. .	. .
24	91	124000	40.2	. . .	. . . .	. . . .	. . . .	16×14	14×14	12×14	. .	. .
	95	149400	50.5	. . .	. . . .	. . . .	. . . .	16×16	14×16	14×14	. .	. .
	101	182800	70.0	. . .	. . . .	. . . .	. . . .	18×16	16×16	16×16	. .	. .
	112	226000	109.0	. . .	. . . .	. . . .	. . . .	. . . .	. . .	. . .	. .	. .
26	84	147500	48.0	. . .	. . . .	. . . .	. . . .	18×16	16×14	14×14	. .	. .
	87	177800	60.2	. . .	. . . .	. . . .	. . . .	18×16	16×16	16×16	. .	. .
	93	217500	83.2	. . .	. . . .	. . . .	. . . .	. . .	18×16	"	. .	. .
	102	269200	130.0	. . .	. . . .	. . . .	. . . .	. . . .	. . .	. . .	. .	. .

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TABLE NO. 22 (*Continued*)

HEATING INSTALLATION DATA FOR MULTIVANE FANS

1¼-INCH STATIC PRESSURE (WATER GAUGE) AIR AT 65° F.

ORDINARY RESISTANCE·FOR·FACTORY AND ROUND·HOUSE HEATING SYSTEMS.

Size Fan.	R. P. M.	Vol. Cu. Ft. per Min.	Brake H. P.	Size Motor.	Size Vertical Engine.			Size Horizontal Engine.			Size Pulley.	
					80 lbs. Pres.	100 lbs. Pres.	120 lbs. Pres.	80 lbs. Pres.	100 lbs. Pres.	120 lbs. Pres.	Dia. in.	Face in.
2	1128	1150	.47	1 B	....	....	....	...	...	...	6	3½
	1170	1375	.58	1 B	....	....	....	...	...	...	"	"
	1250	1690	.81	1 B	....	....	....	...	...	...	"	"
	1380	2095	1.3	2 B	....	....	....	...	...	...	"	"
3	900	1790	.73	2 B	....	....	....	...	...	...	7	4
	933	2150	.91	2 B	....	....	....	...	...	...	"	"
	997	2640	1.3	2 B	....	....	....	...	...	...	"	"
	1103	3275	2.0	1 H	....	....	....	...	...	...	"	"
4	748	2600	1.1	1 H	3×2½	3×2½	3×2½	...	...	...	8	5
	776	3120	1.3	1 H	"	"	"	...	...	...	"	"
	828	3830	1.8	2 H	3×2½	"	"	...	...	...	"	"
	916	4740	2.9	...	....	....	....	...	...	...	"	"
5	642	3500	1.4	2 H	3×2½	3×2½	3×2½	...	...	...	10	5
	667	4200	1.8	2 H	"	"	"	...	...	...	"	"
	712	5160	2.5	2 H	....	"	"	...	...	...	"	"
	787	6400	3.9	3 H	....	....	"	...	...	...	"	"
6	562	4600	1.9	2 H	3½×3	3×2½	3×2½	...	...	...	12	6
	584	5520	2.3	3 H	"	"	"	...	...	...	"	"
	623	6780	3.2	4 H	4×3*	3½×2½*	"	...	...	...	"	"
	690	8400	5.1	4 H	3½×2½*	3½×2½*	....	...	...	...	"	"
6½	502	5870	2.4	3 H	4×4	3½×2½	3×2½	...	...	...	13	6½
	521	7050	3.0	4 H	4×3*	4×3*	3½×3	...	...	...	"	"
	556	8650	4.1	4 H	3½×2½*	"	4×3*	...	...	...	"	"
	615	10700	6.5	6 H	4×3*	"	"	...	...	...	"	"
7	450	7180	2.9	5 H	4×4	4×4	3½×3	...	...	...	14	7½
	467	8620	3.6	5 H	5×5	"	4×4	...	...	...	"	"
	498	10580	5.0	6 H	"	4×3*	"	...	...	...	"	"
	552	13100	7.9	7 H	5×4*	"	4×3*	...	...	...	"	"
8	375	10400	4.2	2 C	5×5	5×5	4×3	...	...	...	16	9
	390	12500	5.3	2 C	"	"	5×5	...	...	...	"	"
	416	15320	7.3	3 C	6×5	"	"	...	...	...	"	"
	460	19000	11.5	3 C	7×5	6×5	"	...	...	...	"	"
9	321	14080	5.7	3 C	6×5	5×5	5×5	...	...	...	18	10½
	336	16900	7.2	4 C	"	"	"	...	...	...	"	"
	356	20750	9.9	5 C	7×5	6×5	6×5	...	...	...	"	"
	394	25700	15.5	6 C	8×6	7×5	6×6	...	...	...	"	"
10	281	18470	7.5	4 C	7×5	6×5	5×5	...	...	...	20	10½
	292	22200	9.4	5 C	7×6	7×5	6×5	...	...	...	"	"
	312	27200	13.0	6 C	8×6	"	6×6	...	...	...	"	"
	345	33700	20.4	8 C	9×7	8×6	7×6	...	...	...	"	"
11	249	23200	9.4	6 C	7×6	7×5	6×5	...	...	...	22	12
	259	27900	11.8	8 C	8×6	7×6	6×6	...	...	...	"	"
	276	34200	16.3	8 C	9×7	8×6	7×6	...	...	...	"	"
	306	42400	25.6	10 C	9×8	9×7	8×7	8×10	...	...	"	"

NOTE. — engines marked with * are double engines.

Continued on next page.

TABLE NO. 22 (*Continued*)

HEATING INSTALLATION DATA FOR MULTIVANE FANS

1¼-INCH STATIC PRESSURE (WATER GAUGE) AIR AT 65° F.

ORDINARY RESISTANCE FOR FACTORY AND ROUND HOUSE HEATING SYSTEMS.

Size Fan.	R. P. M.	Vol. Cu. Ft. per Min.	Brake H. P.	Size Motor.	Size Vertical Engine.			Size Horizontal Engine.			Size Pulley.	
					80 lbs. Pres.	100 lbs. Pres.	120 lbs. Pres.	80 lbs. Pres.	100 lbs. Pres.	120 lbs. Pres.	Dia. in.	Face in.
12	225	28700	11.6	8 C	8×7	7×7	7×6	. . .	. . .	. . .	24	12
	234	34450	14.6	10 C	9×7	8×6	"	. . .	. . .	. . .	"	"
	249	42300	20.2	12½ C	9×8	9×7	8×7	8×10	. . .	. . .	"	"
	276	52300	31.7	12½ C	10×9	10×8	9×8	10×10	8×10	8×10	"	"
13	204	34800	14.1	12½ C	9×7	8×7	7×7	8×10	. . .	. . .	28	13½
	212	41800	17.7	15 C	9×8	8×8	8×7	"	. . .	. . .	"	"
	226	51300	24.4	15 C	10×9	9×8	8×8	10×10	8×10	8×10	"	"
	250	63500	38.4	15 C	11×10	10×9	9×9	11×10	10×10	10×10	. .	. .
14	187	41700	16.9	15 C	10×8	9×7	8×7	10×10	. . .	. . .	32	13½
	195	50000	21.2	15 C	10×9	9×8	8×8	"	8×10	. . .	"	"
	208	61400	29.2	19 C	11×10	10×9	9×8	11×10	10×10	8×10	"	"
	230	76000	46.0	24 C	. . . .	11×10	10×10	12×12	11×10	10×10	. .	. .
15	173	48800	19.8	19 C	10×9	9×9	9×8	10×10	8×10	. . .	36	14½
	180	58500	24.8	19 C	11×9	10×9	"	11×10	10×10	8×10	"	"
	192	72000	34.3	24 C	12×10	11×10	10×9	12×12	11×10	10×10	. .	. .
	212	89000	53.8	24 C	. . . .	12×10	11×10	13×12	12×12	10×12	. .	. .
16	160	56400	22.8	19 C	11×10	10×9	9×8	10×12	10×10	8×10	42	14½
	167	67700	28.6	24 C	12×10	10×10	10×9	12×12	"	10×10	"	"
	178	83100	39.6	29 C	. . . .	12×10	11×10	"	12×12	10×12	. .	. .
	197	102800	62.2	. . .	. . . .	. . . .	. . . .	14×14	13×12	12×12	. .	. .
17	150	64800	26.2	19 C	12×10	11×9	10×9	12×12	10×10	10×10	48	14½
	156	77700	32.9	24 C	12×10	11×10	10×10	"	11×10	"	. .	. .
	166	95500	45.5	29 C	. . . .	12×10	11×10	14×12	12×12	12×12	. .	. .
	184	118200	71.5	. . .	. . . .	. . . .	. . . .	14×16	14×12	12×14	. .	. .
18	141	73500	29.8	34 C	. . . .	11×10	10×10	12×12	11×10	10×10	. .	. .
	146	88200	37.3	34 C	. . . .	12×10	11×10	13×12	12×12	10×12	. .	. .
	156	108100	51.6	34 C	. . . .	. . . .	. . . .	14×14	13×12	12×12	. .	. .
	172	134000	81.2	. . .	. . . .	. . . .	. . . .	16×16	14×14	14×14	. .	. .
20	125	92800	37.6	. . .	. . . .	. . . .	. . . .	14×12	12×12	12×12	. .	. .
	130	111200	47.2	. . .	. . . .	. . . .	. . . .	14×16	14×12	"	. .	. .
	139	136700	65.2	. . .	. . . .	. . . .	. . . .	16×16	14×14	14×14	. .	. .
	153	169200	102.	. . .	. . . .	. . . .	. . . .	18×16	16×16	14×16	. .	. .
22	113	114800	46.5	. . .	. . . .	. . . .	. . . .	16×14	14×12	12×14	. .	. .
	117	137700	58.3	. . .	. . . .	. . . .	. . . .	16×16	14×16	14×14	. .	. .
	125	169000	80.6	. . .	. . . .	. . . .	. . . .	18×16	16×16	14×16	. .	. .
	138	209500	127.	. . .	. . . .	. . . .	. . . .	. . .	18×16	16×16	. .	. .
24	102	138800	56.2	. . .	. . . .	. . . .	. . . .	16×16	16×14	14×14	. .	. .
	106	166700	70.5	. . .	. . . .	. . . .	. . . .	18×16	16×16	14×16	. .	. .
	113	204500	97.6	. . .	. . . .	. . . .	. . . .	. . .	18×16	16×16	. .	. .
	125	253200	153.	. . .	. . . .	. . . .	. . . .	. . .	. . .	. . .	. .	. .
26	94	165000	67.0	. . .	. . . .	. . . .	. . . .	18×16	16×16	16×16	. .	. .
	97	198000	83.8	. . .	. . . .	. . . .	. . . .	. . .	18×16	"	. .	. .
	104	243000	116.	. . .	. . . .	. . . .	. . . .	. . .	. . .	. . .	. .	. .
	115	301000	182.	. . .	. . . .	. . . .	. . . .	. . .	. . .	. . .	. .	. .

Continued on next page.

TABLE NO. 22 (*Continued*)

HEATING INSTALLATION DATA FOR MULTIVANE FANS

1½-INCH STATIC PRESSURE (WATER GAUGE) AIR AT 65° F.

MAXIMUM RESISTANCE FOR FACTORY AND ROUND HOUSE HEATING SYSTEMS.

Size Fan.	R. P. M.	Vol. Cu. Ft. per Min.	Brake H. P.	Size Motor.	Size Vertical Engine.			Size Horizontal Engine.			Size Pulley.	
					80 lbs. Pres.	100 lbs. Pres.	120 lbs. Pres.	80 lbs. Pres.	100 lbs. Pres.	120 lbs. Pres.	Dia. in.	Face in.
2	1223	1260	.61	1 B	. . . .	. . . .	. . . .	. . .	. . .	. . .	6	3½
	1282	1515	.77	1 B	. . . .	. . . .	. . . .	. . .	. . .	. . .	"	"
	1366	1850	1.1	1 B	. . . .	. . . .	. . . .	. . .	. . .	. . .	"	"
	1510	2300	1.7	2 B	. . . .	. . . .	. . . .	. . .	. . .	. . .	"	"
3	985	1960	.95	2 B	. . . .	. . . .	. . . .	. . .	. . .	. . .	7	4
	1022	2360	1.2	2 B	. . . .	. . . .	. . . .	. . .	. . .	. . .	"	"
	1091	2895	1.7	1 H	. . . .	. . . .	. . . .	. . .	. . .	. . .	"	"
	1206	3590	2.6	1 H	. . . .	. . . .	. . . .	. . .	. . .	. . .	"	"
4	820	2840	1.4	1 H	3×2½	3×2½	3×2½	. . .	. . .	. . .	8	5
	852	3420	1.7	2 H	"	"	"	. . .	. . .	. . .	"	"
	908	4190	2.4	2 H	. . . .	. . . .	"	"	. . .	. . .	"	"
	1005	5190	3.8	3 H	. . . .	. . . .	. . . .	. . .	. . .	. . .	"	"
5	703	3830	1.9	2 H	3×2½	3×2½	3×2½	. . .	. . .	. . .	10	5
	730	4620	2.3	2 H	3½×2½	"	"	. . .	. . .	. . .	"	"
	780	5650	3.2	3 H	"	. . . .	. . . .	. . .	. . .	. . .	"	"
	861	7000	5.1	4 H	. . . .	. . . .	. . . .	. . .	. . .	. . .	"	"
6	615	5040	2.5	3 H	3½×3	3½×3	3×2½	. . .	. . .	. . .	12	6
	640	6060	3.1	3 H	3½×3	"	"	. . .	. . .	. . .	"	"
	682	7420	4.3	4 H	3½×2½*	3½×2½*	3½×2½*	. . .	. . .	. . .	"	"
	754	9200	6.7	5 H	. . . .	"	3½×2½*	. . .	. . .	. . .	"	"
6½	549	6430	3.1	4 H	3½×3	4×3	3½×2½	. . .	. . .	. . .	13	6½
	571	7740	3.9	4 H	3½×2½*	"	"	. . .	. . .	. . .	"	"
	610	9470	5.4	5 H	4×3*	"	4×3	. . .	. . .	. . .	"	"
	673	11750	8.5	7 H	"	4×3*	3½×2½*	. . .	. . .	. . .	"	"
7	492	7850	3.8	5 H	3½×2½*	3½×3	3½×3	. . .	. . .	. . .	14	7½
	512	9450	4.8	5 H	4×3*	3½×2½*	"	. . .	. . .	. . .	"	"
	545	11560	6.7	6 H	"	4×3*	3½×2½*	. . .	. . .	. . .	"	"
	603	14350	10.5	7 H	. . . .	. . . .	4×3*	. . .	. . .	. . .	"	"
8	411	11400	5.5	3 C	5×5	5×5	4×3*	. . .	. . .	. . .	16	9
	427	13700	7.0	3 C	6×5	"	"	. . .	. . .	. . .	"	"
	455	16800	9.6	8 H	"	6×5	5×5	. . .	. . .	. . .	"	"
	502	20800	15.1	9 H	6×5*	5×4*	5×4*	. . .	. . .	. . .	"	"
9	352	15400	7.5	3 C	6×5	6×5	5×5	. . .	. . .	. . .	18	10½
	366	18550	9.4	4 C	7×5	"	"	. . .	. . .	. . .	"	"
	390	22700	13.0	9 H	7×6	6×6	6×5	. . .	. . .	. . .	"	"
	431	28200	20.4	8 C	8×6	7×6	6×6	. . .	. . .	. . .	"	"
10	308	20200	9.8	5 C	7×6	6×5	6×5	. . .	. . .	. . .	20	10½
	320	24350	12.4	6 C	"	6×6	"	. . .	. . .	. . .	"	"
	342	29800	17.1	6 C	8×7	7×6	7×6	. . .	. . .	. . .	"	"
	377	37000	26.8	10 C	9×7	8×7	7×7	. . .	. . .	. . .	"	"
11	273	25400	12.4	8 C	8×6	7×6	6×6	. . .	. . .	. . .	22	12
	284	30600	15.5	8 C	8×7	7×7	7×6	. . .	. . .	. . .	"	"
	303	37500	21.5	10 C	9×7	8×7	7×7	8×10	. . .	. . .	"	"
	335	46500	33.6	12½ C	10×8	9×8	8×8	8×10	8×10	. . .	"	"

NOTE. — Engines marked * are double engines.

Continued on next page.

TABLE NO. 22 (*Concluded*)

HEATING INSTALLATION DATA FOR MULTIVANE FANS

1½-INCH STATIC PRESSURE (WATER GAUGE) AIR AT 65° F.

MAXIMUM RESISTANCE FOR FACTORY AND ROUND HOUSE HEATING SYSTEMS.

Size Fan.	R. P. M.	Vol. Cu. Ft. per Min.	Brake H. P.	Size Motor.	Size Vertical Engine.			Size Horizontal Engine.			Size Pulley.	
					80 lbs. Pres.	100 lbs. Pres.	120 lbs. Pres.	80 lbs. Pres.	100 lbs. Pres.	120 lbs. Pres.	Dia. in.	Face in.
12	246	31400	15.3	10 C	8×7	8×6	7×6	. . .	. . .	. . .	24	12
	256	37800	19.2	12½ C	9×8	8×7	8×7	8×10	. . .	. . .	"	"
	273	46300	26.6	12½ C	10×8	9×7	"	10×10	8×10	. . .	"	"
	302	57500	41.6	24 C	10×10	10×8	9×8	11×10	10×10	8×10	"	"
13	224	38100	18.5	15 C	9×8	8×8	8×7	8×10	. . .	. . .	28	13½
	233	45900	23.3	15 C	10×8	9×8	8×8	10×10	8×10	. . .	"	"
	248	56000	32.2	24 C	10×10	10×8	9×8	"	10×10	8×10	"	"
	264	69600	50.5	. . .	12×10	11×9	10×9	12×12	11×10	10×10	. .	. .
14	205	45500	22.2	15 C	10×9	9×8	8×8	10×10	8×10	. . .	32	13½
	213	54800	27.8	19 C	11×9	10×8	9×8	"	10×10	8×10	"	"
	227	67100	38.5	24 C	12×10	10×10	10×9	12×12	"	10×10	"	"
	251	83300	60.5	. . .	. . . .	12×10	11×10	13×12	12×12	10×12	. .	. .
15	190	53400	26.0	19 C	11×9	10×8	9×8	10×12	10×10	8×10	36	14½
	197	64300	32.6	24 C	11×10	10×10	10×9	12×12	"	10×10	"	"
	210	78700	45.2	24 C	12×10	12×10	10×10	"	12×12	"	"	"
	232	97600	70.8	. . .	. . . .	. . . .	. . . .	14×12	13×12	12×12	. .	. .
16	176	61700	30.0	24 C	12×10	11×9	10×9	12×12	10×10	10×10	42	14½
	183	74300	37.7	24 C	12×10	11×10	10×10	"	11×10	"	"	. .
	195	91000	52.2	. . .	. . . .	12×10	11×10	14×12	12×12	12×12	. .	. .
	215	112800	81.7	. . .	. . . .	. . . .	. . . .	14×16	14×12	12×14	. .	. .
17	165	70900	34.5	29 C	12×10	11×10	10×10	12×12	11×10	10×10	48	14½
	171	85500	43.3	34 C	. . . .	12×10	11×10	13×12	12×12	12×12	"	. .
	182	104500	60.0	. . .	. . . .	. . . .	. . . .	14×14	13×12	"	. .	. .
	201	129600	94.0	. . .	. . . .	. . . .	. . . .	16×14	14×14	14×14	. .	. .
18	154	80500	39.0	34 C	. . . .	12×10	11×10	13×12	12×12	10×12	. .	. .
	160	97000	49.2	. . .	. . . .	. . . .	. . . .	14×14	"	12×12	. .	. .
	171	118500	68.0	. . .	. . . .	. . . .	. . . .	14×16	14×12	12×14	. .	. .
	189	147000	107.	. . .	. . . .	. . . .	. . . .	18×16	16×14	14×14	. .	. .
20	137	101600	49.5	. . .	. . . .	. . . .	. . . .	14×16	14×12	12×12	. .	. .
	142	122300	62.2	. . .	. . . .	. . . .	. . . .	16×14	14×14	12×14	. .	. .
	152	149500	86.0	. . .	. . . .	. . . .	. . . .	18×16	16×14	14×14	. .	. .
	168	185600	135.	. . .	. . . .	. . . .	. . . .	. . .	18×16	16×16	. .	. .
22	123	125500	61.0	. . .	. . . .	. . . .	. . . .	16×16	14×16	14×14	. .	. .
	128	151200	76.8	. . .	. . . .	. . . .	. . . .	18×16	16×14	14×16	. .	. .
	137	185000	106.	. . .	. . . .	. . . .	. . . .	. . .	18×16	16×16	. .	. .
	151	230000	166.	. . .	. . . .	. . . .	. . . .	. . .	. . .	. . .	. .	. .
24	112	152000	74.0	. . .	. . . .	. . . .	. . . .	18×16	16×16	14×16	. .	. .
	116	183000	93.0	. . .	. . . .	. . . .	. . . .	. . .	18×16	16×16	. .	. .
	124	224000	128.	. . .	. . . .	. . . .	. . . .	. . .	. . .	. . .	. .	. .
	137	278000	201.	. . .	. . . .	. . . .	. . . .	. . .	. . .	. . .	. .	. .
26	103	180500	88.0	. . .	. . . .	. . . .	. . . .	. . .	18×16	16×16	. .	. .
	107	217000	110.	. . .	. . . .	. . . .	. . . .	. . .	. . .	. . .	. .	. .
	114	266000	153.	. . .	. . . .	. . . .	. . . .	. . .	. . .	. . .	. .	. .
	126	330000	240.	. . .	. . . .	. . . .	. . . .	. . .	. . .	. . .	. .	. .

TABLE NO. 23

WEIGHTS AND OVERALL DIMENSIONS. SINGLE WIDTH, SINGLE INLET MULTIVANE FANS

	Size of Fan.	FULL HOUSING.						
		Overhung Wheel.			Overhung Pulley.			
		Weight — Lbs.		Overall Dimensions. (In Inches.)	Weight — Lbs.		Overall Dimensions. (In Inches.)	
		Net.	Gross.		Net.	Gross.		
Shipped Whole	2	225	240	$19\frac{1}{8} \times 25\frac{3}{4} \times 24\frac{9}{16}$	. . .	. . .	. . . .	
	3	320	335	$23\frac{3}{4} \times 31 \times 30\frac{3}{8}$	. . .	. . .	. . . .	
	4	470	500	$28\frac{3}{4} \times 35\frac{1}{8} \times 36\frac{3}{8}$	. . .	. . .	. . . .	
	5	640	670	$33\frac{1}{4} \times 39\frac{1}{16} \times 41\frac{5}{8}$	. . .	. . .	. . . .	
	6	840	880	$38 \times 45\frac{7}{8} \times 49$	580	610	$38 \times 46\frac{5}{8} \times 49$	Shipped Whole
	6½	1040	1090	$42\frac{7}{8} \times 49\frac{9}{16} \times 54\frac{3}{16}$	755	790	$42\frac{7}{8} \times 52 \times 54\frac{3}{16}$	
	7	1240	1300	$47\frac{1}{4} \times 53\frac{13}{16} \times 59\frac{3}{8}$	925	970	$47\frac{1}{4} \times 55\frac{3}{4} \times 59\frac{3}{8}$	
	8	1800	1880	$56\frac{3}{4} \times 62\frac{1}{2} \times 70\frac{1}{8}$	1260	1320	$56\frac{3}{4} \times 65 \times 70\frac{1}{8}$	
	9	2440	2550	$66\frac{1}{4} \times 71\frac{1}{2} \times 81\frac{5}{8}$	1750	1830	$66\frac{1}{4} \times 75 \times 81\frac{5}{8}$	
	10	3000	3135	$75\frac{1}{2} \times 77\frac{3}{8} \times 92\frac{3}{4}$	2450	2560	$75\frac{1}{2} \times 82 \times 92\frac{3}{4}$	
	11	3675	3842	$85 \times 88\frac{1}{8} \times 104$	3050	3190	$85 \times 90\frac{3}{8} \times 104$	
	12	4350	4550	$94\frac{1}{4} \times 86\frac{7}{16} \times 116\frac{1}{4}$	3700	3870	$94\frac{1}{4} \times 97\frac{7}{8} \times 116\frac{1}{4}$	
	13	5100	. . .	SHIPPED KNOCKED DOWN	4600	. . .	SHIPPED KNOCKED DOWN	
	14	6050	. . .		5350	. . .		
	15	7350	. . .		6650	. . .		
	16	8850	. . .		7800	. . .		
	17	10400	. . .		9360	. . .		
		HOUSING.						
Shipped Whole	10	2600	2740	$80\frac{1}{4} \times 73\frac{1}{4} \times 69\frac{1}{4}$	2200	2320	$80\frac{1}{4} \times 79\frac{1}{4} \times 69\frac{1}{4}$	Shipped Whole
	11	3225	3395	$90\frac{1}{2} \times 81 \times 77\frac{3}{8}$	2750	2900	$90\frac{1}{2} \times 87\frac{5}{8} \times 77\frac{3}{8}$	
	12	3950	4160	$100\frac{1}{4} \times 86\frac{7}{16} \times 86\frac{3}{4}$	3350	3530	$100\frac{1}{4} \times 95\frac{3}{8} \times 86\frac{3}{4}$	
	13	4750	5000	$110\frac{1}{4} \times 95\frac{11}{16} \times 95$	4000	4220	$110\frac{1}{4} \times 104\frac{5}{8} \times 95$	
	14	5700	6000	$120\frac{1}{2} \times 101\frac{1}{16} \times 103\frac{1}{8}$	4750	5000	$120\frac{1}{2} \times 110\frac{1}{2} \times 103\frac{1}{8}$	
	15	6850	7220	$130\frac{3}{4} \times 110\frac{13}{16} \times 111$	5550	5850	$130\frac{3}{4} \times 121\frac{7}{8} \times 111$	
	16	8200	8650	$140\frac{1}{2} \times 119\frac{5}{16} \times 119\frac{1}{8}$	6500	6850	$140\frac{1}{2} \times 130\frac{1}{8} \times 119\frac{1}{8}$	
	17	9900	10440	$150\frac{3}{8} \times 128\frac{1}{16} \times 127\frac{1}{4}$	7650	8070	$150\frac{3}{8} \times 138\frac{5}{8} \times 127\frac{1}{4}$	
	18	. .	. . .	. . . .	8950	. . .	SHIPPED KNOCKED DOWN	
	20	. .	. . .	. . . .	11800	. . .		
	22	. .	. . .	. . . .	15300	. . .		
	24	. .	. . .	. . . .	18650	. . .		
	26	. .	. . .	. . . .	23700	. . .		

NOTE. — These weights and dimensions are for Bottom Horizontal Discharge Fans; those for other discharges will be slightly different. Fans larger than No. 12, Full Housing, and No. 17, ⅞ Housing, are shipped knocked down.

TABLE NO. 24

SIZES, CAPACITIES AND WEIGHTS, STURTEVANT STEEL PLATE FANS WITH FULL HOUSINGS

Size.	Capacities.						Wheel Diam.	Outside Diam. of Inlet.	Outside Diam. of Outlet.	Overall Dimensions.			Weight not Packed.		Pulley.	
	R. P. M.	C. F. M.	H. P.	R. P. M.	C. F. M.	H. P.				Length.	Width.	Height.	Overhung Wheel.	Overhung Pulley.	Diam.	Face.
30	900	1,420	.47	1,272	2,030	1.31	18	11	11	28	27½	29⅝	290	....	5¼	5
35	771	2,010	.65	1,090	2,830	1.83	21	13	13	33	31⅞	34¾	435	....	6	6
40	676	2,600	.85	954	3,690	2.4	24	15	14¾	39	35	41¾	547	....	6¾	6½
45	600	3,400	1.10	850	4,760	3.1	27	17	16⅞	44⅜	38⅞	46½	755	....	8	7½
50	540	4,180	1.36	764	5,900	3.8	30	19	18¾	48⅝	42⅞	51⅛	963	667	8½	8½
60	450	6,169	2.00	636	8,668	5.6	36	27½	22¾	55¾	45¾	60¾	1,198	915	14	6½
70	386	7,921	2.60	545	11,130	7.2	40	30	25¾	63	52½	70	1,694	1,204	16	7½
80	338	10,735	3.50	477	15,085	9.7	48	34	24¾×28½	69½	57⅞	80	1,720	1,450	18	7½
90	300	13,334	4.30	425	18,758	12.0	54	38⅞	28¾×30½	78¼	65⅛	90	2,360	1,675	20	8½
100	270	16,170	5.20	382	22,735	14.5	60	42⅜	32¾×32½	85⅛	69⅛	93	2,690	2,020	20	8½
110	246	20,396	6.60	348	28,679	18.5	66	47	36¾×36½	94	74½	106	....	2,655	22	9½
120	226	27,798	9.0	318	39,098	25.0	72	52¼	42⅞×42⅝	102½	78⅝	114	....	3,250	24	10½
140	193	36,273	11.5	273	50,793	33.0	84	60½	48⅞×48⅝	115½	84¾	132½	....	4,500	28	12½
160	169	40,623	13.0	239	57,065	37.0	96	68½	48⅞×54⅝	133½	88½	147	....	5,584	32	12½
180	150	50,850	16.5	212	71,416	46.0	108	77	55 ×60¾	151½	94½	170	....	6,100	36	12½
200	135	67,460	22.0	191	94,807	61.0	120	85½	61 ×72¾	171	103¼	188	....	7,200	42	12½
220	123	76,500	26.5	173	112,800	72.4	132	94	66¾×78¾	188	104	210	....	8,400	48	12½
240	112	94,000	30.0	159	132,210	85.0	144	102½	73 ×84¾	207	116	230	....	9,500	48	14½

Continued on next page.

TABLE NO. 24 (*Concluded*)

STURTEVANT STEEL PLATE FANS, THREE QUARTER HOUSING

Size.	Capacities.						Diam. Wheel Inches.	Outside Diam. of Inlet.	Dimensions of Outlet.	Outside Dimensions.			Pulley.	
	R. P. M.	C. F. M.	H. P.	R. P. M.	C. F. M.	H. P.				Length.	Width.	Height.	Diam.	Face.
80	338	10,735	3.5	477	15,085	9.7	48	34	28½×24¾	70	50	50	18	7½
90	300	13,334	4.3	425	18,758	12.0	54	38⅞	30½×28¾	78	55	57	20	8½
100	270	16,170	5.2	382	22,735	14.5	60	42⅜	32¾×32½	86	59	63	20	8½
110	246	20,396	6.6	348	28,679	18.5	66	47	36¾×36½	94	64	67	22	9½
120	226	27,798	9.0	318	39,098	25.0	72	52¼	42⅞×42⅝	102	73	75	24	10½
140	193	36,273	11.5	273	50,793	33.0	84	60½	48⅞×48⅝	118	81	85¼	28	12½
160	169	40,623	13.0	239	57,065	37.0	96	68½	54⅞×48⅝	134	84	99¼	32	12½
180	150	50,850	16.5	212	71,416	46.0	108	77	60¾×55	152	90	112	..	..
200	130	67,460	22.0	191	94,807	61.0	120	85½	72¾×61	168	97	124	..	..
220	123	84,300	27.5	174	118,500	76.2	132	94	84 ×66	188	104	138	..	..
240	112	94,000	30.0	159	132,210	85.0	144	102½	84¾×73	208	112	150	..	..
260	104	107,500	35.0	147	150,500	97.5	156	111½	90¾×78	224	119	161½	..	..
280	97	123,000	40.5	137	173,500	111.5	168	120	96¾×84	240	138	174	..	..
300	90	140,500	46.0	128	197,500	127.0	180	128½	102¾×90	258	146	187	..	..
320	85	162,000	53.0	120	228,000	146.5	192	137	111×96	272	154	200	..	..
360	73	204,500	67.0	106	288,000	185.0	216	150	125×108	315	168	224	..	..
400	68	252,000	82.5	96	354,000	228.0	240	170	138⅝×120	350	180	253	..	..

NOTE.—All dimensions are for Bottom Horizontal Discharge Fans.

TABLE NO. 25

SIZES AND CAPACITIES — MONOGRAM FANS (Cast Iron)

Size.	Capacities.						Dia. Wheel.	O. S. Dia. Inlet.	O. S. Dia. Outlet.	Extreme Dimensions.			Pulley.		Weight Not Pkd.	
	R. P. M.	C. F. M.	H. P.	R. P. M.	C. F. M.	H. P.				Length.	Width.	Height.	Dia.	Face.	Blower.	Ex-hauster.
0000	4640	90	.08	6530	130	.23	6	3⅝	2¾	9⅝	8⅛	10	1⅞	1¼	15	20
00	3370	198	.16	4750	267	.49	8¼	4⅞	4⅛	14⅞	12½	14¼	2⅝	1⅞	30	40
0	2855	373	.33	4020	525	.91	9¾	5¾	4¾	17⅞	14¾	16½	3	2½	52	58
1	2560	532	.46	3600	746	1.3	10⅞	6½	5¾	19⅞	16½	19⅛	3½	2½	80	90
2	2270	775	.67	3200	1090	1.9	12¼	7½	7½	24¼	18⅞	22½	4⅜	3¼	120	123
3	1885	1090	.97	2655	1537	2.7	14¾	9	9	28⅜	21½	26½	5⅛	4	190	200
4	1590	1502	1.3	2240	2113	3.8	17½	10½	10⅝	32¾	24½	31	6	4¾	265	300
5	1390	2090	1.8	1960	2950	5.2	20	12¼	12¼	37⅞	28⅛	36¼	6⅞	5¼	380	400
6	1185	3356	2.9	1665	4735	8.4	23½	15	14⅝	43¼	32⅛	41⅞	8	6½	525	590
7	1030	4757	4.3	1450	6700	11.8	27	16⅝	16⅝	50	38¼	50	8⅞	7½	925	1030
8	900	6498	5.7	1265	9153	16.2	31	18⅝	18¾	56⅜	45½	56⅝	10¼	8⅞	1340	1555
9	695	10113	8.9	980	14238	25.1	40	21½	21¾	64½	50½	65¾	12	10½	1975	2100
10	605	14690	12.9	850	20679	36.6	46	24½	24⅝	75	60½	77½	13¾	11¼	2550	2700
MONOGRAM FANS (Pressed Steel)																
0000	4640	90	.08	6530	130	.23	6	3¾	2¾	9⅝	8⅞	9¾	1⅞	1¼	13	
00	3370	198	.16	4750	267	.49	8¼	5¾	4⅛	14⅝	12⅜	13¾	2⅝	1⅞	24	
0	2855	373	.33	4020	525	.91	9¾	6½	4¾	17 9/16	14⅞	16 3/16	3	2½	37	
1	2560	532	.46	3600	746	1.3	10⅞	7½	5¾	19⅞	17⅜	18¼	3½	2½	59	
2	2270	775	.67	3200	1090	1.9	12¼	9	7½	24 3/16	21⅛	21 15/16	4⅜	3¼	88	

TABLE NO. 26

STURTEVANT ELECTRIC PROPELLER FANS

Size. Inches.	Capacities.						Diam. of Wheel, Inches.	Extreme Dimensions.								
	Medium Speed.			Maximum Speed.				Medium Speed.				Maximum Speed.				
	R. P. M.	C. F. M.	H. P.	R. P. M.	C. F. M.	H. P.		Length.	Width.	Height.	Wgt. not Packed.	Length.	Width.	Height.	Wgt. not Packed.	
18	800	1,470	.10	1,000	1,840	.19	18	$14\frac{1}{8}$	$23\frac{1}{4}$	$23\frac{1}{4}$	115	$14\frac{1}{8}$	$23\frac{1}{4}$	$23\frac{1}{4}$	115	Direct Current, Sturtevant Type
24	600	2,610	.17	800	3,480	.41	24	$14\frac{1}{8}$	31	31	165	$19\frac{1}{16}$	31	31	230	
30	500	4,260	.31	675	5,750	.75	30	$19\frac{1}{16}$	38	38	280	$21\frac{15}{16}$	38	38	330	
36	425	6,250	.46	550	8,100	1.00	36	$22\frac{1}{2}$	44	44	380	26	44	44	440	
42	350	8,170	.57	470	11,000	1.36	42	26	$52\frac{1}{4}$	$52\frac{1}{4}$	575	$29\frac{7}{16}$	$52\frac{1}{4}$	$52\frac{1}{4}$	760	
48	300	10,400	.69	410	14,300	1.76	48	$28\frac{7}{16}$	59	59	825	$33\frac{3}{4}$	59	59	925	
54	260	12,900	.81	365	18,100	2.24	54	$33\frac{3}{4}$	$65\frac{1}{2}$	$65\frac{1}{2}$	1,025	$24\frac{1}{2}$	$65\frac{1}{2}$	$65\frac{1}{2}$	900	
60	235	16,000	1.01	325	22,100	2.68	60	26	70	70	1,000	26	70	70	1,000	
18	900	1,575	.12	1,200	2,100	.28	18	$12\frac{3}{8}$	$21\frac{1}{4}$	$21\frac{1}{4}$	175	$11\frac{7}{8}$	$21\frac{1}{4}$	$21\frac{1}{4}$	175	Alternating Current, Sturtevant Type
24	600	2,480	.15	900	3,720	.50	24	$15\frac{1}{2}$	$27\frac{3}{4}$	$27\frac{3}{4}$	250	15	$27\frac{3}{4}$	$27\frac{3}{4}$	250	
30	600	4,850	.45	720	5,840	.78	30	$17\frac{15}{16}$	$34\frac{1}{4}$	$34\frac{1}{4}$	400	$17\frac{15}{16}$	$34\frac{1}{4}$	$34\frac{1}{4}$	400	
36	450	6,250	.46	600	8,400	1.12	36	$21\frac{1}{8}$	$41\frac{7}{8}$	$41\frac{7}{8}$	500	$19\frac{1}{8}$	$41\frac{7}{8}$	$41\frac{7}{8}$	500	
18	800	2,670	.15	1,000	3,350	.28	18	$14\frac{5}{8}$	$23\frac{1}{4}$	$23\frac{1}{4}$	115	$18\frac{3}{16}$	$23\frac{1}{4}$	$23\frac{1}{4}$	180	Direct Current, Blackman Type
24	600	4,750	.26	800	6,330	.62	24	$19\frac{1}{16}$	31	31	200	$21\frac{3}{8}$	31	31	225	
30	500	7,750	.47	675	10,430	1.13	30	$23\frac{7}{16}$	$37\frac{3}{8}$	$37\frac{3}{8}$	350	$27\frac{3}{16}$	$37\frac{3}{8}$	$37\frac{3}{8}$	438	
36	425	11,400	.69	550	14,700	1.50	36	29	44	44	500	$32\frac{1}{4}$	44	44	550	
42	350	14,850	.86	470	20,000	2.04	42	$32\frac{1}{2}$	$52\frac{1}{4}$	$52\frac{1}{4}$	720	$34\frac{7}{8}$	$52\frac{1}{4}$	$52\frac{1}{4}$	950	
48	300	18,900	1.04	410	26,000	2.64	48	$35\frac{1}{8}$	59	59	1,000	$27\frac{5}{8}$	59	59	1,156	
54	260	23,500	1.22	365	32,900	3.36	54	28	$65\frac{1}{2}$	$65\frac{1}{2}$	1,100	$29\frac{1}{4}$	$65\frac{1}{2}$	$65\frac{1}{2}$	1,200	
60	235	29,100	1.52	325	40,200	4.02	60	29	70	70	1,300	$30\frac{1}{2}$	70	70	1,400	
18	900	2,865	.18	1,200	3,820	.42	18	$12\frac{7}{8}$	$21\frac{1}{4}$	$21\frac{1}{4}$	150	$13\frac{3}{8}$	$21\frac{1}{4}$	$21\frac{1}{4}$	150	Alternating Current, Blackman Type
24	600	4,510	.23	900	6,770	.75	24	$16\frac{3}{8}$	$27\frac{3}{4}$	$27\frac{3}{4}$	300	$17\frac{5}{8}$	$27\frac{3}{4}$	$27\frac{3}{4}$	300	
30	600	7,360	.39	720	10,600	1.17	30	$22\frac{1}{8}$	$31\frac{1}{4}$	$31\frac{1}{4}$	440	$22\frac{1}{8}$	$31\frac{1}{4}$	$31\frac{1}{4}$	440	
36	450	11,370	.69	600	15,280	1.68	36	$25\frac{3}{8}$	$41\frac{7}{8}$	$41\frac{7}{8}$	560	$25\frac{3}{8}$	$41\frac{7}{8}$	$41\frac{7}{8}$	560	

TABLE NO. 27

STURTEVANT DISC FANS

Size.	R. P. M.	C. F. M.	H. P.	Pulley.		Net Weight.
				Diam.	Face.	
18	800	1,670	.15	4	2½	100
24	600	2,960	.26	5	2½	132
30	500	4,850	.47	6	3½	166
36	425	7,100	.69	7	4½	190
42	350	9,280	.86	8	5½	290
48	300	11,800	1.04	8	5½	350
54	260	14,700	1.22	9	5½	425
60	235	18,200	1.52	10	6½	535
66	210	21,600	1.74	10	6½	665
72	195	26,000	2.15	12	7½	875
78	180	30,600	2.54	14	8½	1,000
84	165	35,000	2.82	14	8½	1,025
96	145	46,000	3.70	16	10½	1,175
108	130	58,600	4.84	18	12½	1,470
120	115	71,000	5.70	20	12½	1,800

TABLE NO. 28

READY-TO-RUN VENTILATING SETS

Size.	For General Application.								Telephone Booth.		
	Speed.	Volume Wide Open c. f. m.	Shaft Watts.	Height.	Outside Diameter Inlet.	Outside Diameter Discharge.	Net Weight A. C.	Net Weight D. C.	Normal Speed.	Shaft Watts.	No. of Booths.
A	850	35	.55	9	4⅛	$3\frac{1}{16}$	15	15	850	.55	1
	1150	50	1.35						1150	1.05	2
	1750	75	4.75								
	3400	150	35.00								
B	1150	120	4.60	12	5⅛	$3\frac{13}{16}$	17	17	1150	2.75	3
	1750	180	16.25				17	17			
	3400	350	120.00				28	28			
C	1150	250	24.40	14	6⅛	$5\frac{3}{16}$	32	32	1150	14.00	3
	1750	400	86.00								4
D	850	450	46.00	18⅛	8⅝	6⅞	43	43	850	25.00	6
	1150	600	115.00				56	60			7
	1750	950	410.00				141	175			8
E	700	775	90.00	22⅝	11¼	7¾	165	123	700	49.00	9
	850	925	168.00				165	128			10
	1150	1150	415.00				176	292			11
											12

NOTE.—The above data for machines wound for either 110 or 220 volts direct current and 110 or 220 volts, 60 cycles single phase alternating current. D size 1750 R. P. M. and E size all three speeds may be furnished either single or three phase A. C.

TABLE NO. 29

VS-7 AND VS-8 ENGINES

High and Medium Pressure.

Size.	Max. R. P. M.	Horse Powers at Varying Steam Pressures.														
		60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
4×5	500	4.0	5.0	5.5	6.5	7.5	8.5	9.5	10.0	11.0	12.0	12.5	13.5	14.0	15	16.0
5×5		6.0	7.5	9.0	10.5	12.0	13.0	14.5	16.0	17.5	18.5					
6×5		9.5	11.5	13.5	15.0	17.0	19.0	21.0	23.0							
7×5		13.0	15.5	18.0	21.0	23.5										
5×6	475	7.5	9.0	10.5	12.0	13.5	15.0	16.5	18.0	19.5	21.0	22.5	24.0	25.5	27	28.5
6×6		11.0	13.0	15.5	17.5	20.0	22.5	24.5	26.5	29.0	31.0					
7×6		14.5	17.5	20.5	24.0	27.0	30.0	33.0	36.0							
8×6		19.5	23.5	27.0	31.0	35.0										
6×7	425	11.5	13.5	16.0	18.0	20.5	23.0	25.0	27.0	29.5	32.0	34.0	36.5	39.0	41	43.5
7×7		15.5	18.5	21.5	25.0	28.0	31.0	34.0	37.5	40.5	44.0					
8×7		20.5	24.5	28.5	33.0	37.0	41.5	45.5	50.0							
9×7		26.0	31.0	36.0	41.5	46.6										
7×8	400	16.5	19.5	23.0	26.5	30.0	33.0	36.0	39.5	42.5	46.0	50.0	53.0	57.0	60	64.0
8×8		22.0	26.5	31.0	35.0	39.5	44.0	48.5	53.0	57.5	62.0					
9×8		27.5	33.5	39.0	44.5	50.0	55.5	61.0	66.5							
10×8		34.5	41.0	48.0	55.0	62.0										
8×9	375	23.0	27.5	32.0	36.5	41.0	46.0	50.5	55.0	59.5	65.0	69.5	74.0	78.5	83	88.0
9×9		29.0	35.0	41.0	47.0	53.0	59.0	64.5	70.0	76.0	82.0					
10×9		36.0	43.5	51.0	58.0	65.0	72.5	80.0	88.0							
11×9		43.5	52.0	61.0	70.0	79.0										
9×10	350	30.0	36.0	42.5	48.5	54.0	60.5	66.0	72.5	78.5	84.5	91.0	97.0	103.0	110	117.0
10×10		37.5	45.0	52.5	60.0	68.0	75.5	83.0	91.0	99.0	106.0					
11×10		45.0	54.0	63.5	73.0	82.0	91.0	100.0	109.0							
12×10		54.0	65.0	76.0	87.0	98.0										
10×12	300	38.0	46.0	54.0	62.0	70.5	76.5	85.0	93.0	100.0	108.0	114.0	123.0	131.0	138	146.0
11×12		46.5	55.0	64.5	73.5	82.0	91.5	101.0	110.0	120.0	129.0	138.0	148.0	158.0		
12×12		56.0	70.0	78.0	90.0	101.0	112.0	123.0	135.0	145.0	156.0					
13×12		65.0	78.0	92.0	105.0	118.0	131.0	143.0	153.0							
14×12		75.0	90.0	105.0	120.0	136.0	151.0									
		30	40	50	60	70	80									
16×12	300	28.0	49.5	73.0	94.0	118.0	138.0									

Low Pressure

		15	20	25	30	35	40	50	60
8×5	400	2.0	3.0	5.0	7.0	8.5	10.5	14.5	18.0
12×6	375	4.5	8.5	12.5	17.0	21.5	26.0		
14×7	350	8.5	14.0	21.0	26.0	33.0	40.0		
18×8	300	14.0	21.5	30.0	39.0				

Size.	Pipes.		Weight Not Packed.	Overall Dimensions.		
	Steam.	Exhst.		Length.	Width.	Height.
4×5	1¼	1½	1150			62½
5×5	1¼	1½	1150	34⅛	26	62½
6×5	1½	2	1175			63⅛
7×5	1½	2	1200			63½
8×5	2	2½	1250	34⅛	26	67 11/16
5×6	1½	2	1625			70⅛
6×6	1½	2	1625	40 1/16	30	70⅛
7×6	2	2½	1650			75½
8×6	2	2½	1675			77 11/16
12×6	3	3½	2100	39 9/16	30	83
6×7	2	2½	2275			83¾
7×7	2	2½	2275	45½	34	83¾
8×7	2½	3	2350	45½	34	84 9/16
9×7	2½	3	2425			84 13/16
14×7	3½	4	3025	45⅛	34	90 7/16
7×8	2½	3	3075			89⅜
8×8	2½	3	3075	50⅜	36	89⅜
9×8	3	3½	3175			93⅝
10×8	3	3½	3275			94¼
18×8	4½	5	3950	52 5/16	36	100 13/16
8×9	3	3½	3600			103 5/16
9×9	3	3½	3600	54½	36	103 5/16
10×9	3	3½	3725			103 1/16
11×9	3	3½	3850			102 9/16
9×10	3	3½	4475			109¼
10×10	3	3½	4475	60 1/16	42	109¼
11×10	3	3½	4625			108 1/16
12×10	3½	4	4775			110 3/16
10×12	3	3½	7850			135½
11×12	3½	4	7850			135½
12×12	4	4½	7850	70⅝	54	135½
13×12	4	4½	8050			135⅝
14×12	5	6	8050			135⅝
16×12	5	6	8250			138⅝

NOTE. — H. P. is based on maximum speed and ⅙ cut off for High and Medium Pressure Engines. Non-condensing
H. P. is based on maximum speed and ½ cut off for Low Pressure Engines. Non-condensing.

TABLE NO. 30.

HC-1 ENGINES

Size.	Pipes.		Weight not Packed.	Overall Dimensions.			Max. R. P. M.	Horse Powers at Varying Steam Pressures.														
	Steam.	Exhaust.		Length.	Width.	Height.		60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
7×10	2½	3	5350	94	52⅞	47¼	350	. .	. .	. .	. .	. .	. .	. .	. .	. .	53.5	55	58.5	62.5	66	69
8×10	2½	3	5350	94	52⅞	47¼		24.0	29	34.0	39.0	43.5	48.5	53.0	58	63	68.0					
10×10	3	3½	5725	97¼	55⅛	50¼		37.5	45	52.5	60.0	68.0	75.5	83.0	91							
11×10	3½	4	5800	97 7/16	55⅛	50¼		45.0	54	63.5	73.0	82.0										
9×12	3	3½	7900	109⅝	63⅞	59	300	. .	. .	. .	. .	. .	. .	. .	. .	. .	87.5	92	99.0	106.0	113	120
10×12	3	3½	7900	109⅝	63⅞	59		38.0	46	54.0	62.0	70.0	77.0	85.0	93	100	108.0					
12×12	4	4½	8600	113⅝	65⅞	62		56.0	67	78.0	90.0	101.0	112.0	123.0	135							
13×12	4	4½	8700	113¾	65⅞	62		65.0	78	92.0	105.0	118.0	131.0									
14×12	5	6	9000	117⅛	65⅞	62		75.0	90	106.0	121.0	136.0										
10×14	4	5	13300	129¼	72⅞	69	275	. .	. .	. .	. .	. .	. .	. .	. .	. .	113.0	122	130.0	139.0	147	155
12×14	4	5	13300	129¼	72⅞	69		59.0	71	83.0	95.0	107.0	119.0	130.0	142	155	166.0					
14×14	5	6	13500	130¼	72⅞	69		81.0	97	113.0	130.0	146.0	162.0	179.0	195							
16×14	5	6	13700	133⅛	72⅞	69		105.0	126	147.0	168.0	189.0										
12×16	5	6	20950	148⅞	80¾	76	250	. .	. .	. .	. .	. .	. .	. .	. .	. .	168.0	182	195.0	207.0	218	230
14×16	5	6	20950	148⅞	80¾	76		83.0	100	117.0	134.0	150.0	167.0	184.0	200	218	234.0					
16×16	5	6	21250	147¼	80¾	76		112.9	135	157.0	180.0	202.0	225.0	247.0	270							
18×16	6	7	21550	148⅝	80¾	76		140.0	168	196.0	225.0	253.0										
								LOW PRESSURE														
								10	15	20	25	30	35	40	45	50	55	60				
12×8	3	3½	3500	78⅜	47 5/16	39¾	275	3.0	5	9.5	13.0	17.4	22.0	26.8								
15×8	3	3½	3800	78⅛	47 5/16	39¾	250	4.0	10	15.5	21.0											
15×10	3	3½	6000	98 7/16	55⅛	50¼	225	4.5	12	19.0	25.0	31.0	37.0	43.0	75							
18×12	5	6	9700	115½	65⅞	62	200	6.5	18	28.0	38.0	47.0	56.0	65.0								
24×14	6	7	13800	134⅜	72⅞	69	175	17.5	30	48.0	67.5	86.0	105.0	125.0								

TABLE NO. 31

TYPE "H" MOTORS

Frame Size.	110 Volts.			220 Volts.			Dimensions.			Dia. Shaft.	Pulley.		Weight not Packed.
	Full Load Speed.	H. P.	Cat. No.	Full Load Speed	H. P.	Cat. No.	Length.	Width.	Height.		Dia.	Face.	
1 H	1630	4.0	1010	1630	4.0	2010	20⅛	19⅜	21¼	1¼	5	4	448
	1295	3.0	1030	1295	3.0	2030							
	1070	3.0	1050	1070	3.0	2050							
	790	2.0	1070	790	2.0	2070							
	510	1.5	1100	510	1.5	2100							
2 H	1440	6.0	1130	1440	6.0	2130	23¼	20⅝	22¼	1⅜	6	4	517
	1110	4.0	1150	1110	4.0	2150							
	903	4.0	1170	903	4.0	2170							
	700	3.0	1190	700	3.0	2190							
	478	2.0	1220	478	2.0	2220							
3 H	1366	9.0	1250	1366	9.0	2250	24 5/16	22	24	1⅜	7¾	5	650
	1015	6.0	1280	1015	6.0	2280							
	804	5.0	1300	804	5.0	2300							
	563	3.5	1330	563	3.5	2330							
	383	2.5	1360	383	2.5	2360							
4 H	1386	10.0	1370	1386	10.0	2370	26 11/16	23½	26¼	1	8	6	826
	978	7.5	1410	978	7.5	2410							
	852	6.0	1420	852	6.0	2420							
	611	5.0	1440	611	5.0	2440							
	409	3.0	1470	409	3.0	2470							
5 H	1190	14.0	1490	1190	14.0	2490	30⅛	26⅛	28⅛	2	9	7	1107
	988	14.0	1510	988	14.0	2510							
	733	8.0	1540	733	8.0	2540							
	579	6.0	1560	579	6.0	2560							
	478	6.0	1580	478	6.0	2580							
6 H	1267	16.0	1600	1267	16.0	2600	35⅛	28⅝	30¾	2	10	7	1475
	1007	14.0	1620	1007	14.0	2620							
	834	14.0	1640	834	14.0	2640							
	710	10.0	1660	710	10.0	2660							
	488	6.0	1690	488	6.0	2690							
7 H	984	26.0	1720	984	26.0	2720	38⅞	30¾	34⅛	2¼	11	8	1896
	790	22.0	1740	790	22.0	2740							
	655	18.0	1760	655	18.0	2760							
	557	12.5	1780	557	12.5	2780							
	424	10.0	1800	424	10.0	2800							
8 H	947	30.0	1820	947	30.0	2820	43¾	32	36	2⅜	12	8	2330
	727	22.0	1840	727	22.0	2840							
	534	15.0	1860	534	15.0	2860							
	423	15.0	1880	423	15.0	2880							
9 H	823	35.0	1900	823	35.0	2900	49¼	34¼	39	2½	14	9	2899
	630	25.0	1920	630	25.0	2920							
	465	18.0	1940	465	18.0	2940							
	368	18.0	1960	368	18.0	2960							

TABLE NO. 32

TYPE "C" MOTORS

Frame Size.	110 Volts.			220 Volts.			Dimensions.			Dia. Shaft.	Pulley.		Weights.	
	Full Load Speed.	H. P.	Cat. No.	Full Load Speed.	H. P.	Cat. No.	Lgth.	Wth.	Hht.		Dia.	Face.	Net.	Shipping.
1C	625 405 296 185	5.8 3.6 2.8 1.9	5015 5035 5050 5065	625 405 296 185	5.7 3.6 2.1 1.3	6015 6035 6050 6065	23⅛	27	29⅝	1 7/16	8	5	575	660
1½C	635 445 302 207 136	7.6 4.3 3.5 2.7 1.1	5105 5125 5140 5155 5170	635 445 302 207 136	7.3 4.1 2.7 1.9 1.0	6105 6125 6140 6155 6170	23⅝	27	29½	1 7/16	10	6	750	860
2C	530 361 249 165	10.2 7.9 4.7 3.6	5205 5220 5240 5255	530 361 249 165	10.0 7.8 4.6 3.6	6205 6220 6240 6255	29⅛	31½	34⅝	1 15/16	12	6	1050	1230
3C	467 321 191 119	12.5 7.5 4.5 2.4	5310 5325 5340 5355	467 321 191 119	10.0 7.5 4.5 2.5	6310 6325 6340 6355	30	31½	34⅝	1 15/16	14	8	1256	1460
4C	470 317 204 114	15.8 9.6 7.4 3.1	5405 5420 5435 5455	470 317 204 114	15.8 12.5 7.4 4.2	6405 6420 6435 6455	31⅝	35½	38⅜	2 3/16	16	9	1550	1800
5C	480 354 230 120	16.0 12.5 9.8 5.8	5505 5520 5535 5555	480 354 230 120	20.5 16.0 12.5 5.9	6505 6520 6535 6555	33 3/16	35½	39⅝	2 3/16	18	10	1600	1875
6C	393 238 127	20.5 12.4 7.3	5605 5625 5645	393 238 127	26.0 12.4 7.2	6605 6625 6645	36 7/16	38	43	3 7/16	18	12	2075	2400
8C	472 326 197 125	33.0 20.0 15.0 11.5	5700 5715 5735 5755	472 326 197 125	33.0 20.0 15.0 11.5	6700 6715 6735 6755	49¼	48	46¼	3 7/16	20	14	2400	2800
10C	415 257 150 90	37.0 19.5 12.0 9.0	5805 5825 5845 5860	415 257 150 90	37.0 20.0 12.0 9.0	6805 6825 6845 6860	51 11/16	50½	50¼	3 15/16	22	14	2950	3425
12½C	354 220 147 115	41.0 19.0 14.5 11.0	5905 5925 5940 5950	354 220 147 115	41.0 24.5 19.0 11.0	6905 6925 6940 6950	52⅝	50½	51¼	3 15/16	24	16	4000	4675
15C	288 212 139 101	41.0 32.0 25.0 14.5	7020 7035 7050 7065	288 212 139 101	52.0 32.0 24.5 14.0	8020 8035 8050 8065	52 15/16	56¾	57½	3 15/16	24	18	5300	6200
19C	233 156 110	41.0 32.0 25.0	7120 7135 7150	233 156 110	41.0 24.5 19.0	8120 8135 8150	52 15/16	56¾	57½	3 15/16	26	20	6000	7000
24C	261 160 114 88	50.0 40.0 27.0 23.0	7205 7220 7235 7250	261 160 114 88	66.0 40.0 27.0 21.0	8205 8220 8235 8250	64	62	64	4½	30	22	8000	9500
29C	182 141 114 86	50.0 35.0 31.0 23.0	7315 7325 7335 7350	182 141 114 86	55.0 40.0 30.5 23.5	8315 8325 8335 8350	64	62	64	4½	32	24	9000	10500
34C	159 125 86	65.0 40.0 31.0	7425 7435 7450	184 140 90	53.0 41.0 24.5	8425 8435 8450	75	69⅝	69	5	36	26	12000	14000

TABLE NO. 33

BI-POLAR MOTORS

Frame Size.	110 Volts.			220 Volts.			Overall Dimensions.			Weights not Packed.	Dia. Shaft.	Pulley.	
	Full Load Speed.	H. P.	Cat. No.	Full Load Speed.	H. P.	Cat. No.	Length.	Width.	Height.			Dia.	Face.
¼ B	3549	.58	115	3549	.58	215	15⅜	18	15¼	145	⅝	3	2
¼ B	2417	.35	155	2392	.35	255							
¼ B	1854	.28	170	1854	.28	270							
¼ B	1438	.21	185	1395	.21	285							
¼ B	1162	.17	300	1112	.17	400							
¼ B	869	.11	315	803	.11	415							
½ B	2430	.77	340	2430	.77	440	19 3/16	22½	18 9/16	225	¾	4	2
½ B	1670	.55	365	1670	.55	465							
½ B	1435	.44	380	1435	.44	480							
½ B	1045	.35	395	1045	.35	495							
½ B	805	.28	510	805	.28	610							
1 B	2040	1.97	535	2040	1.97	635	22	27	21⅝	300	⅞	4	3½
1 B	1505	1.40	550	1505	1.40	650							
1 B	1180	1.22	565	1180	1.22	665							
1 B	878	.85	580	878	.85	680							
1 B	565	.57	595	565	.57	695							
2 B	1770	2.84	725	1990	2.84	820	25 17/32	27	23⅜	415	1⅛	5	4
2 B	1255	1.79	745	1255	1.79	845							
2 B	845	1.41	765	845	1.41	865							
2 B	465	.70	785	465	.70	885							

TABLE NO. 34

HOT BLAST APPARATUS

REGULAR, LONDON, AND EXHAUST SECTIONS

Size of Sect.	Nominal Height of Pipes. Ft.	In.	Two Row.		Four Row.		Number of Pipes. 2 Rows.	Width of Jacket	Free Area through Section. Sq. Ft.
			Lineal Feet 1-inch Pipe.	Total Area in Sq. Ft.	Lineal Feet 1-inch Pipe.	Total Area in Sq. Ft.			
3 ft.	3	0	97	39.5	194	76.5	34	37¾	3.85
	3	6	115	45.5	230	88.5	. .	. .	4.52
	4	0	133	52.0	266	101.0	. .	. .	5.21
	4	6	148	57.0	296	111.5	. .	. .	5.76
	5	0	166	63.5	332	124.0	. .	. .	6.46
	5	6	184	69.5	368	136.5	. .	. .	7.12
	6	0	199	75.0	398	146.5	. .	. .	7.67
4 ft.	3	6	156	62.0	312	120.5	46	50¼	5.94
	4	0	180	70.5	360	137.0	. .	. .	6.85
	4	6	200	77.5	400	151.0	. .	. .	7.60
	5	0	225	86.0	450	168.0	. .	. .	8.46
	5	6	249	94.5	498	184.5	. .	. .	9.37
	6	0	270	101.5	540	199.0	. .	. .	10.10
	6	6	294	110.0	588	215.5	. .	. .	11.01
	7	0	319	118.5	638	233.0	. .	. .	11.88
5 ft.	4	0	227	89.0	454	172.5	58	63¼	8.50
	4	6	253	98.0	506	190.5	. .	. .	9.45
	5	0	284	108.5	568	212.0	. .	. .	10.51
	5	6	314	119.0	628	233.0	. .	. .	11.68
	6	0	340	128.0	680	251.0	. .	. .	12.56
	6	6	371	138.5	742	272.0	. .	. .	13.65
	7	0	402	149.5	804	293.5	. .	. .	14.75
	7	6	427	158.0	854	310.5	. .	. .	15.75
	8	0	458	168.5	916	331.5	. .	. .	16.81
6 ft.	4	6	305	118.0	610	230.0	70	76¼	11.29
	5	0	342	131.0	684	255.5	. .	. .	12.60
	5	6	380	144.0	760	282.0	. .	. .	13.89
	6	0	411	155.0	822	303.5	. .	. .	14.96
	6	6	448	167.5	896	329.0	. .	. .	16.32
	7	0	485	180.5	970	354.5	. .	. .	17.64
	7	6	516	191.0	1032	376.0	. .	. .	18.75
	8	0	553	204.0	1106	401.5	. .	. .	20.07
	8	6	584	214.5	1168	422.5	. .	. .	21.18
	9	0	621	227.5	1242	448.0	. .	. .	22.50

Size of Sect.	Nominal Height of Pipes. Ft.	In.	Two-Row Section with 1¼ Inch Pipe			Number of Pipes.	Width of Jacket	Free Area through Section. Sq. Ft.	
			Actual 1¼-inch Pipe.	Equivalent of 1-in. Pipe	Total Area in Sq. Ft.			Standard 1¼-inch Pipe.	Special 1-inch Pipe.
6 ft.	5	0	254	320	125.0	54	72¾	11.25	15.17
	5	6	283	357	137.5	. .	. .	12.53	16.87
	6	0	313	394	150.5	. .	. .	13.75	18.20
	6	6	336	423	160.5	. .	. .	14.80	19.90
	7	0	366	461	173.5	. .	. .	16.00	21.53
	7	6	389	490	183.5	. .	. .	17.00	22.88
	8	0	419	528	196.5	. .	. .	18.26	24.58
	8	6	443	558	207.0	. .	. .	19.20	25.90
	9	0	472	595	219.5	. .	. .	20.50	27.60
7 ft.	5	0	291	367	142.5	62	83¼	12.88	17.32
	5	6	325	410	157.0	. .	. .	14.31	19.24
	6	0	359	452	172.0	. .	. .	15.73	20.80
	6	6	386	486	183.5	. .	. .	16.84	22.71
	7	0	420	529	198.5	. .	. .	18.23	24.62
	7	6	447	563	210.0	. .	. .	19.42	26.14
	8	0	481	606	224.5	. .	. .	20.83	28.05
	8	6	508	640	236.5	. .	. .	21.94	29.58
	9	0	542	683	251.0	. .	. .	23.36	31.49
	9	6	576	726	266.0	. .	. .	24.76	33.06
	10	0	603	760	277.5	. .	. .	25.90	34.96

All types of sections are built in 2-row and 4-row widths and 3, 4, 5, and 6 foot lengths, with 1-inch pipes, also in 2-row width only for 6 and 7 foot lengths with 1¼-inch pipes. These latter sections can be piped with 1-inch, thus giving larger free area between pipes.

TABLE NO. 35

HOT BLAST APPARATUS. MITRE TYPE SECTIONS

Nominal Dimensions.								Number of Pipes 2-Row Section.	Area in Sq. Feet 1-inch Pipe.		Free Area through Section. Sq. Ft.
Length Base.	Length Pipes. Ft.	Width Jacket. Ft.	Ins.	Height Pipes. Ft.	Ins.	Height Jacket. Ft.	Ins.		2-Row.	4-Row.	
3 ft.	3	3	9¼	5	0	5	7½	34	70.5	136.5	6.35
	3	"	"	5	6	6	2	"	76.5	149.0	7.01
	3	"	"	6	0	6	7¼	"	82.0	159.0	7.56
	4	4	10	5	0	5	7½	"	83.0	161.0	7.67
	4	"	"	5	6	6	2	"	89.0	173.5	8.33
4 ft.	4	4	10	6	0	6	7¼	46	110.5	215.0	10.10
	4	"	"	7	0	7	8	"	127.5	248.5	11.84
	4	"	"	8	0	8	7½	"	142.5	279.5	13.44
	5	5	10¾	6	0	6	7¼	"	127.5	248.5	11.84
5 ft.	5	5	10¾	7	0	7	8	58	160.0	312.5	14.76
	5	"	"	8	0	8	7½	"	179.5	352.0	16.74
	5	"	"	9	0	9	7¼	"	198.5	390.5	18.75
	5	"	"	10	0	10	7	"	218.5	430.0	20.73
	6	6	11½	7	0	7	8	"	181.0	355.5	16.91
6 ft.	6	6	11½	8	0	8	7½	70	217.0	425.0	20.00
	6	"	"	9	0	9	7¼	"	240.0	472.0	22.43
	6	"	"	10	0	10	7	"	263.5	519.0	24.82
	6	"	"	11	0	11	7¾	"	289.5	570.5	27.40
	6	"	"	12	0	12	7½	"	313.0	617.5	29.80

Nominal Dimensions.							Number of Pipes 2-Row Section.	Area in Sq. Ft.		Free Area through Section. Sq. Ft. 1¼" Pipe.
Length Base.	Length Pipes. Ft.	Width Jacket. Ft.	Ins.	Height Pipes. Ft.	Height Jacket. Ft.	Ins.		1¼" Pipe.	1" Pipe.	
6 ft.	6	6	9¼	8	8	7	54	211.5	172.0	18.36
	"	"	"	9	9	7	"	234.5	190.5	20.62
	"	"	"	10	10	6¾	"	257.5	208.5	22.85
	"	"	"	11	11	6½	"	280.5	227.0	25.10
	"	"	"	12	12	6½	"	304.0	245.0	27.26
	"	"	"	13	13	7½	"	329.5	. . .	29.75
	"	"	"	14	14	7¼	"	352.5	. . .	31.98
7 ft.	7	7	7¾	9	9	7	62	268.5	218.0	23.54
	"	"	"	10	10	6¾	"	295.0	239.0	26.08
	"	"	"	11	11	6½	"	321.5	260.0	28.61
	"	"	"	12	12	6½	"	348.0	281.0	31.18
	"	"	"	13	12	7½	"	377.5	. . .	34.00
	"	"	"	14	14	7¼	"	404.0	. . .	36.53

TABLE NO. 36

HOT BLAST HEATERS

INLET AND DRIP CONNECTIONS.

Type of Section.	Size of Section. Ft.	Number of Rows.	Width of Section. Ins.	Largest Inlet.			Standard Inlet. Ins.	Largest Drip.			Standard Drip. Ins.
				Indepen. Header. Ins.	In Flange. Ins.	In Section. Ins.		Indepen. Header. Ins.	In Flange. Ins.	In Section. Ins.	
Regular	All	2	4⅛	6	4	. .	. .	3½	2	. .	. .
"	"	4	7¾	6	4	. .	. .	3½	2	. .	. .
London	3	2	4⅛	. .	. .	2½	1½	. .	. .	2	¾
"	3	4	7¾	. .	. .	4	2	. .	. .	2	1
"	4	2	4⅛	. .	. .	2½	1½	. .	. .	2	¾
"	4	4	7¾	. .	. .	4	2	. .	. .	2	1
"	5	2	4⅛	. .	. .	2½	2	. .	. .	2	1
"	5	4	7¾	. .	. .	4	2½	. .	. .	2	1¼
"	6	2	4⅛*	. .	. .	2½	2½	. .	. .	2	1¼
"	6	4	7¾	. .	. .	4	3	. .	. .	2	1½
"	7	2	5⅛	. .	. .	2½	2½	. .	. .	2	1½
Exhaust	3 to 6	2	4	. .	. .	2½	1½	. .	. .	1½	1
"	"	4	7⅝	. .	. .	2½	2½	. .	. .	2	2
"	7	2	5⅛	. .	. .	2½	2½	. .	. .	1½	2

* The width of a 6-foot, 2-row section with 1¼-inch pipe is 5⅛ inches.

Note. — The regular type section has extended head surfaced on both sides for receipt of flange or header. Holes in the circular flange permit of the passing of bolts, which draw a group of these sections together.

In the London type the extended rectangular head is regularly tapped to standard size for independent inlet and drip in accordance with table. If smaller connections are required, bushings may be used, but sections with larger connections (not exceeding the maximum listed sizes) must be made to order.

Exhaust sections are made with the maximum size holes for inlet and drip, and are bushed to order as may be required to match size of fan-engine exhaust pipe.

The inlet on a 4-row mitre type section is always cast for 4-inch pipe but flanged down to required size. The drip on a 4-row and both the inlet and drip on a 2-row are cast and tapped to size required.

TABLE NO. 37

USUAL SIZES OF STEAM CONNECTIONS, HOT BLAST HEATERS

Lineal Feet of 1-inch Pipe in Heater.	Over 80 Pounds.		60 Pounds.		30 Pounds.		5 Pounds and Under.	
	Inlet.	Drip.	Inlet.	Drip.	Inlet.	Drip.	Inlet.	Drip.
1000	1¼	1	1½	1	2	1¼	3	2
2000	1½	1	2	1¼	2½	1½	4	2
3000	2	1¼	2½	1½	3	1½	4½*	2½*
4000	2½	1½	3	1½	3½	2	5*	2½*
5000	3	1½	3½	2	4	2	5*	2½*
6000	3	1½	4	2	5*	2½*	6*	3*

Note. — An intermediate size heater takes connections for the next size *larger* in the table.

Independent supply and drip headers are necessary if inlet or drip pipes exceed 4 inches and 2 inches respectively. Such cases are marked with an asterisk in the above table.

TABLE NO. 38

STANDARD HOT BLAST APPARATUS WITH FULL HOUSING STEEL PLATE FANS

Size of Apparatus.	Steam Supply.	Rows Deep.	Size of Section.	Total Area in Sq. Ft.	Steam Traps.	Weight of		
						Pulley Fan.	Steam Fan.	Heater.
3×4½	Live	14	3 × 4	364	1-1	1000	1250	2800
60 in.	Exhaust	18	3 × 4	468	1-1	1000	1250	3500
3½×5¼	Live	16	3 × 4	416	1-1	1400	1550	3100
70 in.	Exhaust	20	3 × 4	520	1-1	1400	1550	3750
4×6	Live	16	3 × 5	508	1-1	1550	2000	3600
80 in.	Exhaust	20	3 × 5	635	1-2	1550	2000	4400
4½×6¾	Live	16	4 × 5	688	1-2	1750	2300	4550
90 in.	Exhaust	20	4 × 5	860	1-2	1750	2300	5700
5×7½	Live	16	5 × 6	1024	1-3	1950	2600	6500
100 in.	Exhaust	20	5 × 6	1280	1-3	1950	2600	8000
5½×8¼	Live	16	5 × 7	1196	1-3	2600	3200	7300
110 in.	Exhaust	20	5 × 7	1495	1-3	2600	3200	9000
6×9	Live	16	6 × 7	1444	1-4	3550	4200	8600
120 in.	Exhaust	20	6 × 7	1805	1-4	3550	4200	10600
7×10½	Live	16	6 × 8	1632	1-4	4650	5500	9600
140 in.	Exhaust	20	6 × 8	2040	1-4	4650	5500	11800
8×12	Live	16	7 × 9	2008	1-4	5850	7900	13200
160 in.	Exhaust	20	7 × 9	2510	2-3	5850	7900	16250

NOTE. — Areas given in column 5 are based on 2-row heater bases. If 4-row bases are used the areas will be slightly less.

TABLE NO. 39

STANDARD HOT BLAST APPARATUS WITH THREE-QUARTER HOUSING STEEL PLATE FANS

Size of Apparatus.	Steam Supply.	Rows Deep.	Size of Sect.	No. of Group.	Total Area in Square Feet.	Steam Traps.	Weight of		
							Pulley Fan.	Steam Fan.	Heater.
5×2¾	Live	16	5×6	1	1004	1–3	1600	2500	6500
	Exhaust	20	5×6	1	1255	1–3	1600	2500	8000
5½×3	Live	16	6×6	1	1214	1–3	1950	2900	7600
	Exhaust	20	6×6	1	1518	1–3	1950	2900	9400
6×3½	Live	16	4×5	2	1344	2–2	2500	3850	9100
	Exhaust	20	4×5	2	1680	2–2	2500	3850	11250
7×4	Live	16	4×6	2	1592	2–2	3300	5000	9150
	Exhaust	20	4×6	2	1990	2–3	3300	5000	11300
8×4	Live	16	5×6	2	2008	2–3	3950	6300	12650
	Exhaust	20	5×6	2	2510	2–3	3950	6300	15650
9×4½	Live	16	6×6	2	2428	2–3	5000	8300	14900
	Exhaust	20	6×6	2	3035	2–4	5000	8300	18450
10×5	Live	16	6×8	2	3212	2–4	6400	11000	18750
	Exhaust	20	6×8	2	4015	2–4	6400	11000	23250
12×6	Live	16	6×7	3	4254	3–3	8900	13700	25300
	Exhaust	20	6×7	3	5317	3–4	8900	13700	31500

NOTE. — The areas in the sixth column are for 4-row sections of one-inch pipe.

TABLE NO. 40

STEAM TRAPS

No.	Inlet in Ins.	Outlet in Ins.	Capacity for Direct Radiation.	Capacity for Sturtevant Heater.	Weight Not Pkd.
0	¾	¾	1,800 ft. 1-in. pipe	600 ft. 1-in. pipe	40
1	1	1	3,000 " "	1,000 " "	80
2	1¼	1	6,000 " "	2,000 " "	135
3	1½	1¼	10,000 " "	3,500 " "	249
4	2	1½	15,000 " "	5,000 " "	280

TABLE NO. 41

FRICTION EFFECT THROUGH HOT BLAST HEATERS

FRICTION IN INCHES OF WATER. VOLUMES OF AIR AND FRICTION EFFECT TAKEN AT 65° F.

Outside Diam. 1" Pipe = 1.281". Outside Diam. 1¼" Pipe = 1.660"					
Velocity Through Free Area Feet per Min.	Number of Rows in Heater.	1" Pipe 2⅛" Centers.	1¼" Pipe 2⅜" Centers.	1" Pipe 2⅜" Centers.	1" Pipe 2¾" Centers.
600	8	.07	.07	.05	.05
	16	.11	.11	.07	.07
	24	.15	.16	.10	.10
	32	.19	.21	.13	.13
900	8	.15	.16	.11	.11
	16	.24	.26	.17	.16
	24	.34	.37	.23	.21
	32	.44	.48	.29	.27
1200	8	.26	.28	.20	.19
	16	.43	.47	.30	.28
	24	.60	.66	.41	.38
	32	.78	.85	.52	.48
1500	8	.41	.44	.31	.29
	16	.68	.73	.47	.45
	24	.95	1.03	.64	.60
	32	1.22	1.33	.81	.76
1800	8	.59	.63	.44	.42
	16	.98	1.05	.69	.64
	24	1.36	1.48	.93	.86
	32	1.75	1.91	1.17	1.08
2100	8	.80	.86	.61	.58
	16	1.33	1.44	.94	.88
	24	1.85	2.02	1.27	1.18
	32	2.39	2.61	1.60	1.48

TABLE NO. 42

SIZES AND CAPACITIES — STURTEVANT AIR WASHERS

Nominal Size.	Capacity Cubic Feet per Minute.	Width. Ft.	Width. In.	Height. Ft.	Height. In.	Water Supply Pipe. Inches.	Pump Suction Pump. Inches.	Weight Steel Pulley Pump.	Washer of Gal. Electric Pump.
3 × 3	3600–4500	3	3⅛	4	1 11/16	1	1½	840	1200
3 × 4	4800–6000	3	3⅛	5	1 11/16	1	1½	925	1275
3 × 5	6000–7500	3	3⅛	6	1 11/16	1	1½	1015	1360
3 × 6	7200–9000	3	3⅛	7	1 11/16	1½	2	1100	1450
4 × 4	6400–8000	4	3⅛	5	1 11/16	1½	2	1060	1410
4 × 5	8000–10000	4	3⅛	6	1 11/16	1½	2	1145	1495
4 × 6	9600–12000	4	3⅛	7	1 11/16	1½	2	1300	1650
4 × 7	11200–14000	4	3⅛	8	1 11/16	1½	2	1390	1740
5 × 4	8000–10000	5	3⅛	5	1 11/16	1½	2	1240	1590
5 × 5	10000–12500	5	3⅛	6	1 11/16	1½	2	1340	1690
5 × 6	12000–15000	5	3⅛	7	1 11/16	1½	2	1450	1800
5 × 7	14000–17500	5	3⅛	8	1 11/16	2	2½	1650	2000
5 × 8	16000–20000	5	3⅛	9	1 11/16	2	2½	1755	2105
6 × 5	12000–15000	6	3⅛	6	1 11/16	1½	2	1500	1850
6 × 6	14400–18000	6	3⅛	7	1 11/16	2	2½	1700	2050
6 × 7	16800–21000	6	3⅛	8	1 11/16	2	2½	1820	2170
6 × 8	19200–24000	6	3⅛	9	1 11/16	2	2½	2040	2390
6 × 9	21600–27000	6	3⅛	10	1 11/16	2	2½	2170	2520
7 × 6	16800–21000	7	3⅛	7	1 11/16	2	2½	1800	2150
7 × 7	19600–24500	7	3⅛	8	1 11/16	2	2½	2050	2400
7 × 8	22500–28000	7	3⅛	9	1 11/16	2	2½	2190	2540
7 × 9	25200–31500	7	3⅛	10	1 11/16	2	2½	2400	2730
8 × 6	19200–24000	8	3⅛	7	1 11/16	2	2½	2090	2610
8 × 7	22500–28000	8	3⅛	8	1 11/16	2	2½	2255	2780
8 × 8	25600–32000	8	3⅛	9	1 11/16	2½	3	2420	2940
8 × 9	28800–36000	8	3⅛	10	1 11/16	2½	3	2600	3140
8 × 10	32000–40000	8	3⅛	11	1 11/16	2½	3	2780	3300
9 × 8	28800–36000	9	3⅛	9	1 11/16	2½	3	2420	2950
9 × 9	32400–40500	9	3⅛	10	1 11/16	2½	3	2830	3350
9 × 10	36000–45000	9	3⅛	11	1 11/16	2½	3	2970	3490
10 × 8	32000–40000	10	3⅛	9	1 11/16	2½	3	2830	3360
10 × 9	36000–45000	10	3⅛	10	1 11/16	2½	3	3030	3550
10 × 10	40000–50000	10	3⅛	11	1 11/16	2½	3	3210	3740
12 × 8	38400–48000	12	3⅛	9	1 11/16	2½	3	3160	3680
12 × 9	43200–54000	12	3⅛	10	1 11/16	2½	3	3240	3950
12 × 10	48000–60000	12	3⅛	11	1 11/16	3	3½	3650	4490
14 × 8	44800–56000	14	3⅛	9	1 11/16	3	3½	3520	4390
14 × 9	50400–63000	14	3⅛	10	1 11/16	3	3½	3820	4750
14 × 10	56000–70000	14	3⅛	11	1 11/16	3	3½	4150	5020
15 × 8	48000–60000	15	3⅛	9	1 11/16	3	3½	3820	4890
15 × 9	.54000–67500	15	3⅛	10	1 11/16	3	3½	4100	4980
15 × 10	60000–75000	15	3⅛	11	1 11/16	3	3½	4340	5220
16 × 8	51200–64000	16	3⅛	19	1 11/16	3	3½	3980	4850
16 × 9	57600–72000	16	3⅛	10	1 11/16	3	3½	4280	5150
16 × 10	64000–80000	16	3⅛	11	1 11/16	3½	4	4790	5770
18 × 8	57600–72000	18	3⅛	9	1 11/16	3½	4	4600	5590
18 × 9	64800–81000	18	3⅛	10	1 11/16	3½	4	4920	5900
18 × 10	72000–90000	18	3⅛	11	1 11/16	3½	4	5220	6210
20 × 8	64000–80000	20	3⅛	9	1 11/16	3½	4	4930	5900
20 × 9	72000–90000	20	3⅛	10	1 11/16	4	4½	5460	6450
20 × 10	80000–100000	20	3⅛	11	1 11/16	4	4½	5750	6800
22 × 8	70400–88000	22	3⅛	9	1 11/16	4	4½	5600	6670
22 × 9	79200–99000	22	3⅛	10	1 11/16	4	4½	5850	6930
22 × 10	88000–110000	22	3⅛	11	1 11/16	4	4½	6160	7250

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